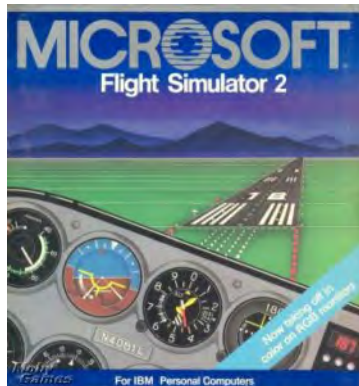




## MANUFACTURING & INNOVATION : 200YRS + LESSONS WITH AN EYE TOWARDS TODAYS COMPUTING

# Tom Lange preparing for his first trip to Bay Area for P&G



Circa ~1987...





As told through one Manufactures 180 year view...by a retired story teller ;-)

# **FIRST SOME MANUFACTURING HISTORY...**

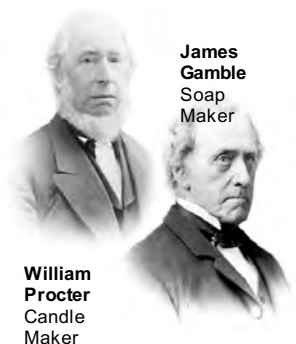
# How Historians Know P&G...

## Founded in 1837



Founded on the  
Banks of the  
Ohio, Cincinnati

**P&G**



William  
Procter  
Candle  
Maker

James  
Gamble  
Soap  
Maker

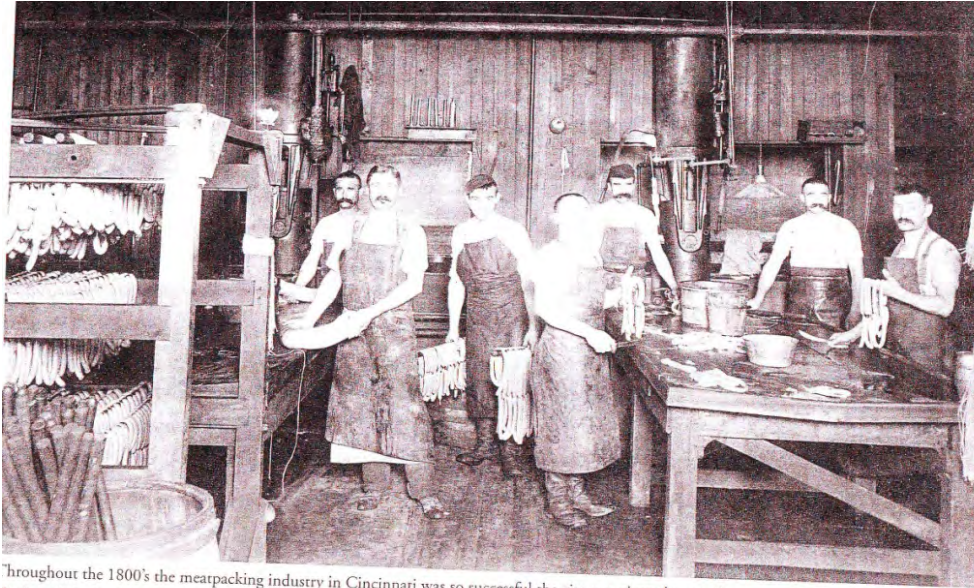
...one of the DOW 30  
4<sup>th</sup> oldest on the  
Fortune 500  
... one of the very few in top  
50 in 1900 and in 2000

# Why Cincinnati?

...Rivers & Pigs

# “Porkopolis” a.k.a. Cincinnati, Ohio

## Cincinnati was the U.S. chief hog packing center



Throughout the 1800's the meatpacking industry in Cincinnati was so successful the city was given the moniker "Porkopolis". In 1880 there were sixty-eight pork and beef packers and twenty-five sausage makers in the city.

Meat was  
stuffed in  
Brine Filled  
Barrels &  
shipped down  
the rivers

Salt Pork,  
Bacon, Sausage  
Were staple  
foods



# The Great 19<sup>th</sup> Century Industrial Cities

...Grew up near waterways.



# P&G biggest Seller in 1862 ...STAR Candles...

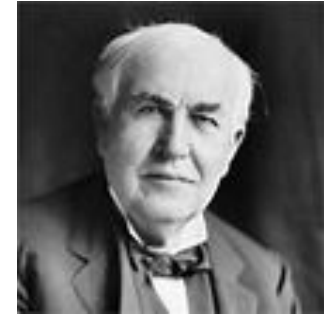


Thomas Edison  
~ age 15 was  
a telegraph  
runner to the  
P&G Candle  
Factory

P&G actually sold



*Light*





# Why did P&G Soap sales surpass Candles in 1876?

- The discovery of oil in 1859 in Pennsylvania made kerosene readily available.



# By 1898...What was their *Next BIG Thing?*

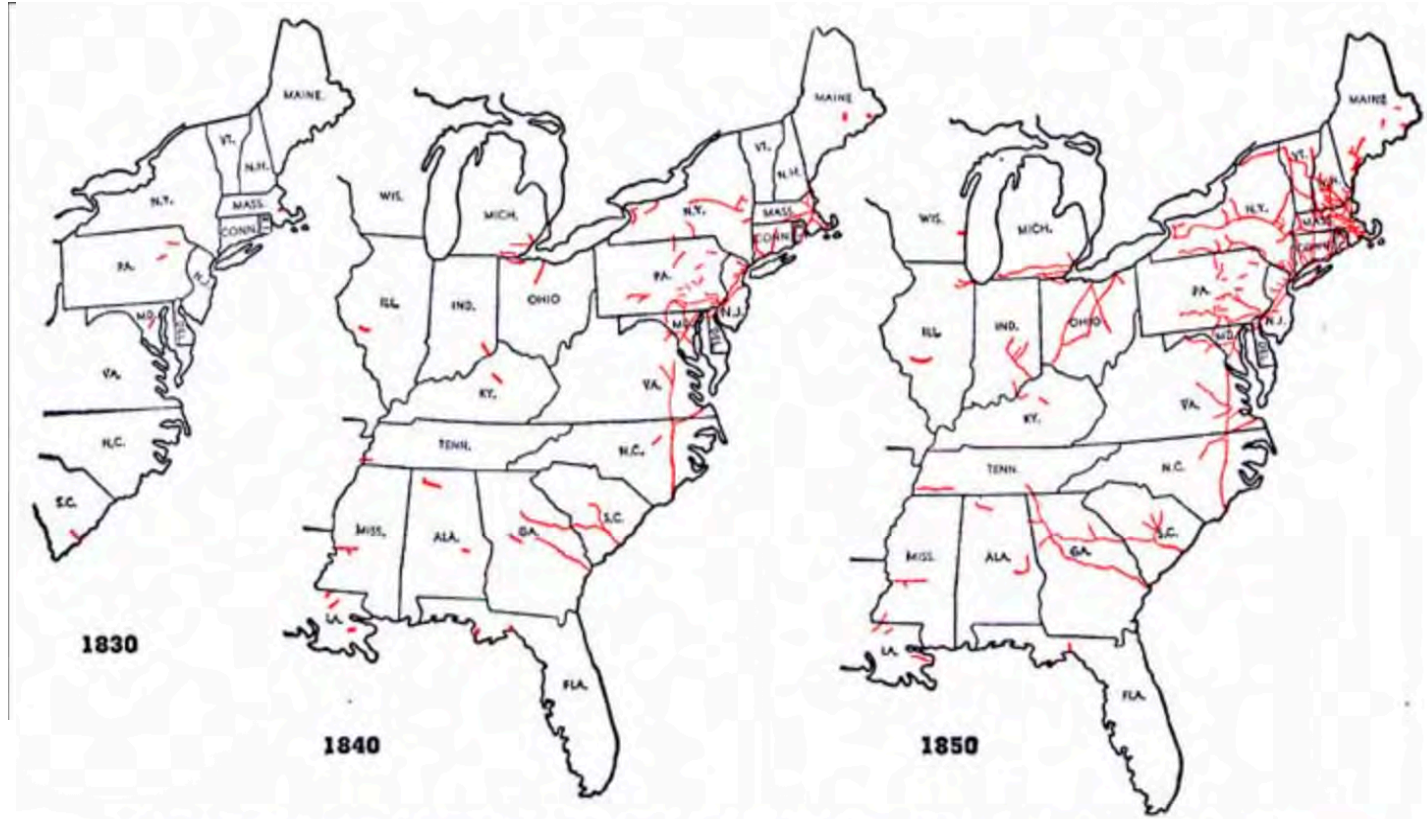


# Travel Around the world...33 days!

“The Russian minister of communication has stated that when the **great Trans-Siberian railroad** is opened, early in the twentieth century, the tour of the world can be completed in thirty-three days.”

Scientific American ... December 1898

# Railroad Network... 1830 to 1890



# At the speed of the Wind, Water, or Animal...

- Prior to Rail...  
**Communication**  
was only as fast  
as walking,  
water or  
animals...



Wooden  
Oar &  
Sailing  
Ships



~5-10  
MPH...

~ TONS OF  
CARGO

# WHAT ICONIC RETAILER LEVERAGED THAT INNOVATION ?





Richard Warren Sears

Richard Warren Sears was a railroad station agent in North Redwood, MN... Circa 1880's

**SEARS, ROEBUCK & CO.**

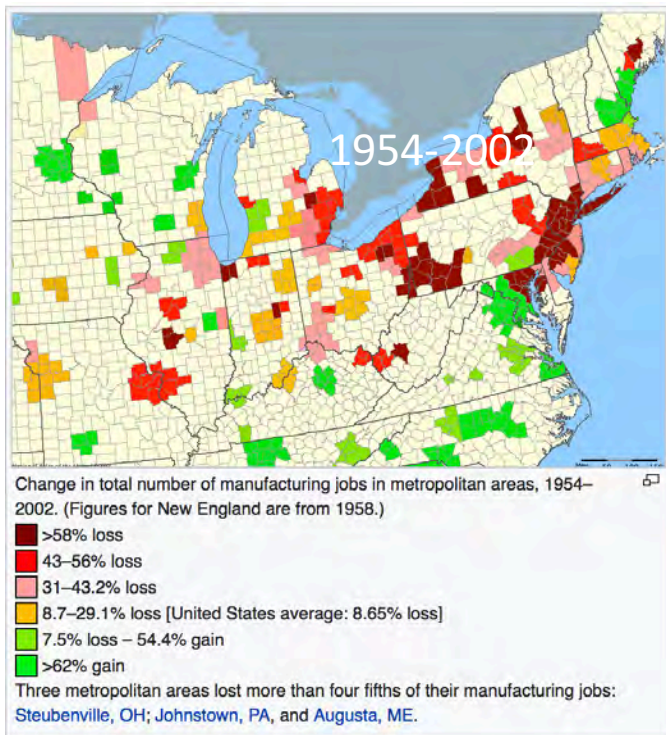
WE SELL EVERYTHING BY MAIL ORDER ONLY. YOUR MONEY WILL BE PROMPTLY RETURNED FOR ANY GOODS NOT PERFECTLY SATISFACTORY AND WE WILL PAY FREIGHT OR EXPRESS CHARGES BOTH WAYS

By 1890... Chicago was the 2<sup>nd</sup> largest city in the U.S. with over \$1M People.

It was not just because of SEARS  
catalogue sales reaching 'everywhere' ...

but manufacturing everything that  
SEARS sold!... From steel to door knobs

# U.S. 'Industrial Belt' grows

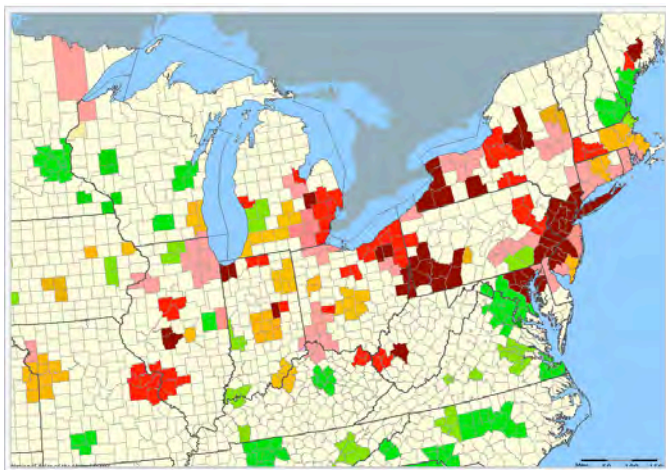


Movement of  
goods and  
information...from  
WATER, and then  
to RAIL, was the  
explosive enabler  
of prosperity

...

# But that industrial 'belt' ... Rusted

# Why?



Change in total number of manufacturing jobs in metropolitan areas, 1954–2002. (Figures for New England are from 1958.)

- >58% loss
- 43–56% loss
- 31–43.2% loss
- 8.7–29.1% loss [United States average: 8.65% loss]
- 7.5% loss – 54.4% gain
- >62% gain

Three metropolitan areas lost more than four fifths of their manufacturing jobs:  
[Steubenville, OH](#); [Johnstown, PA](#), and [Augusta, ME](#).

# Even for P&G manufacturing became unneeded

## **Procter & Gamble To Shut City Plant 275 Jobs To Be Cut On North Ave**

Side

July 20, 1989 | By Pamela Sherrod.

Procter & Gamble Manufacturing Co.  
said Wednesday it is closing its 59-  
year-old Chicago plant and eliminating  
275 jobs

`After a thorough economic analysis of the company`s  
business, a decision has been made to consolidate at other  
locations the manufacture of bar soaps and glycerine now  
made in our Chicago plant, `` said Karl Schaulin.

# What Company is this?

- Began as a small chain of specialty retail stores in a major city
- ~20 years later migrated from specialty to become mainstream & grocery products retailer
- First to Introduce 'economy store concept' and grew to 1600 stores.
- ~30 year later became the world's largest retailer... with 16,000 stores.



# History of A&P

- Founded in 1859
- After WW1 Added Meat & Produce to 'Dry Groceries'
- Reached \$1B in sales in 1930...worlds largest retailer
- 1936 Adopted 'Self-Serve' Concept
- Decline began by 1950
- Filed Chapter 11 in 2010
- Became Private 2012



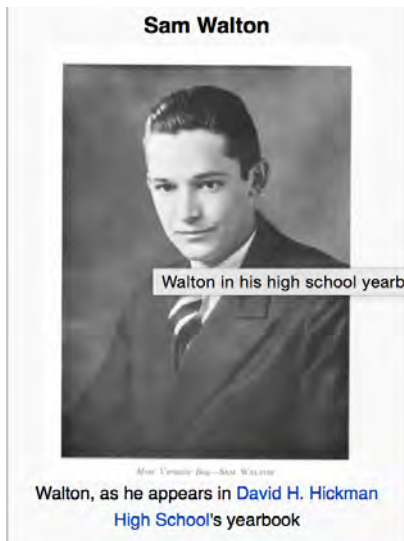
**What Disruptive  
Innovations  
shaped A&P's history...both  
growth and demise.**

# Unintended Consequences of a Military Decision

## Interstate Highways



# Winners with Interstate Highways...



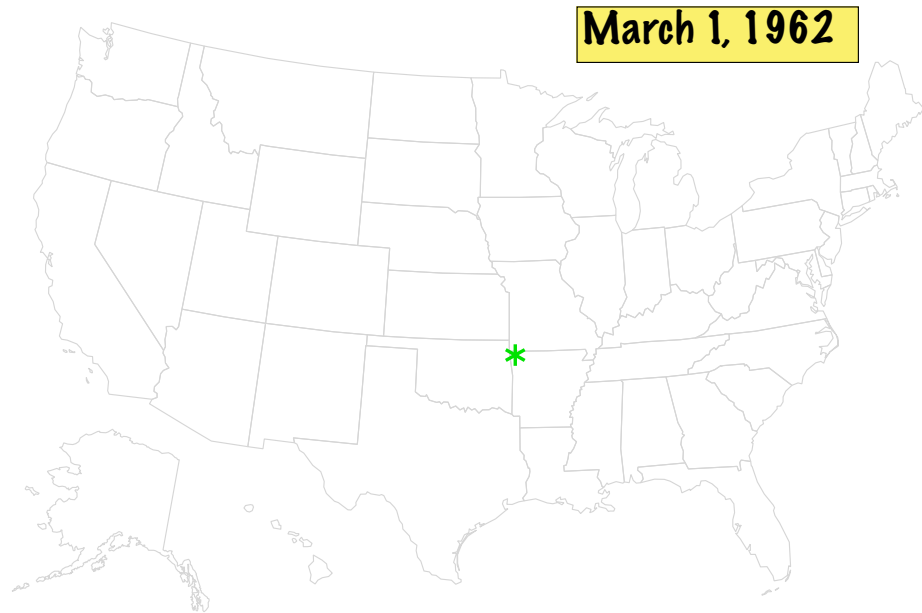
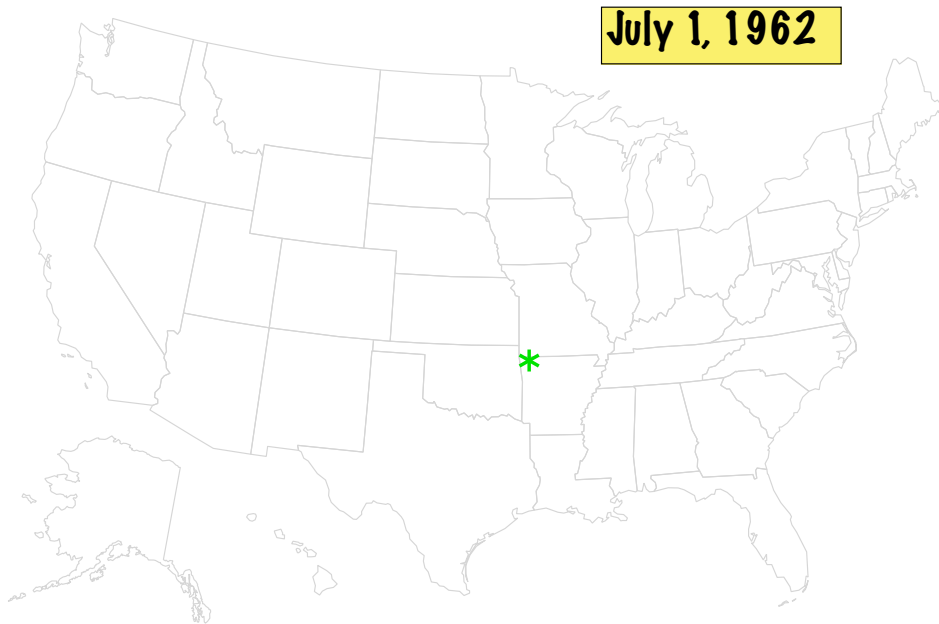
**Education:** David H. Hickman High School  
· University of Missouri



“To make his model work, he emphasized logistics, particularly locating stores within a day’s drive proximity to Wal-Mart’s regional warehouses, and distributed through its own trucking services”

- Store Openings

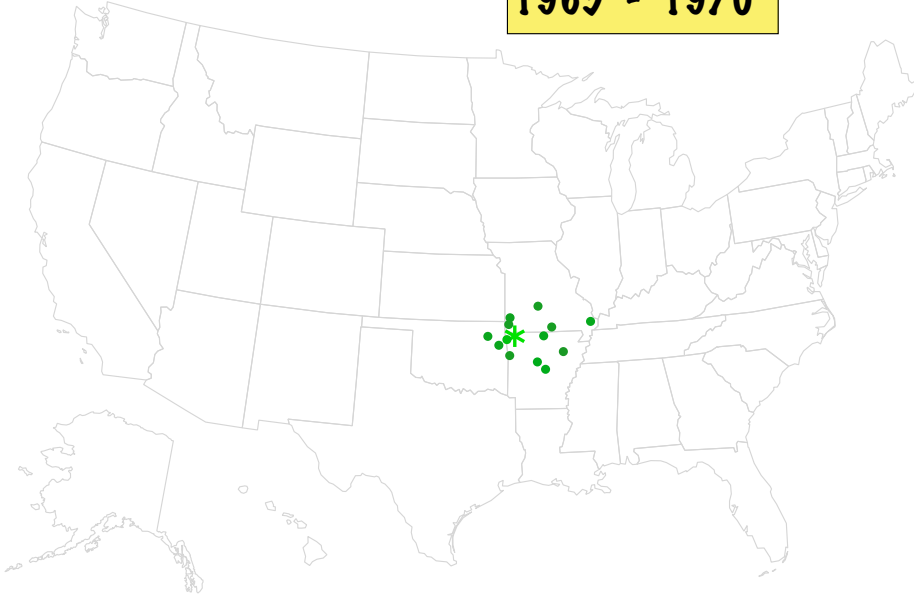
- Distribution Centers



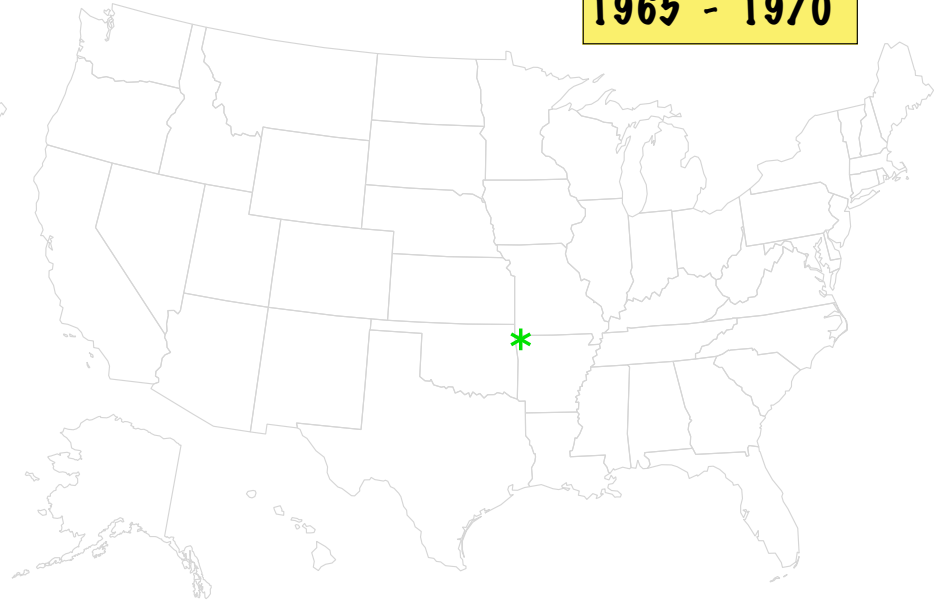
- Store Openings

- Distribution Centers

1965 - 1970



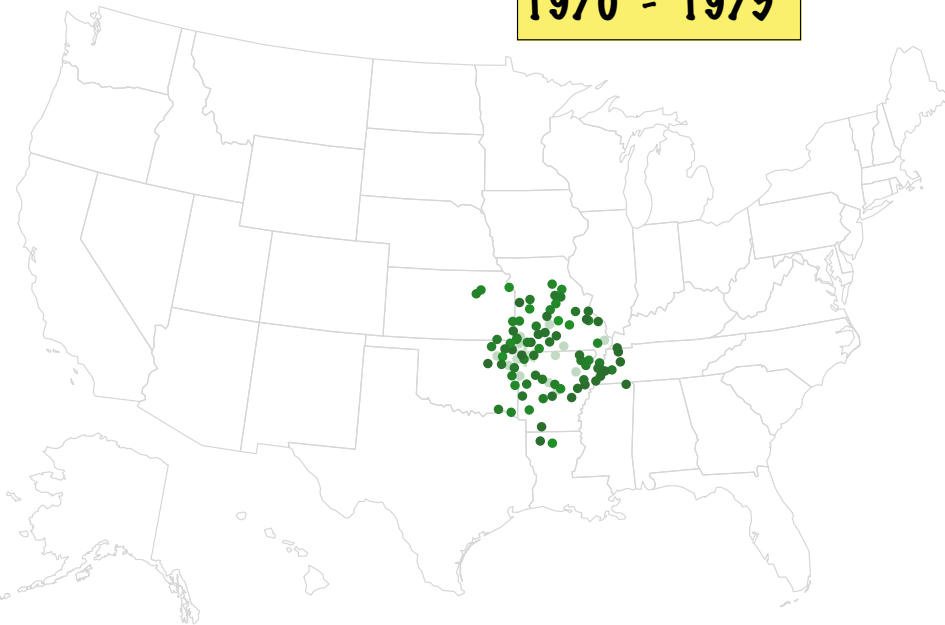
1965 - 1970



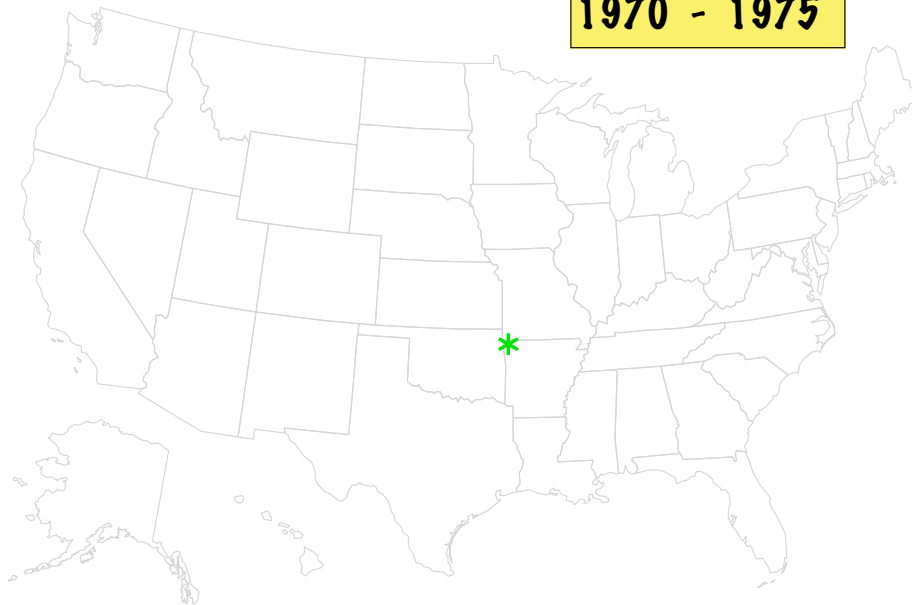


- Store Openings
- Distribution Centers

1970 - 1975



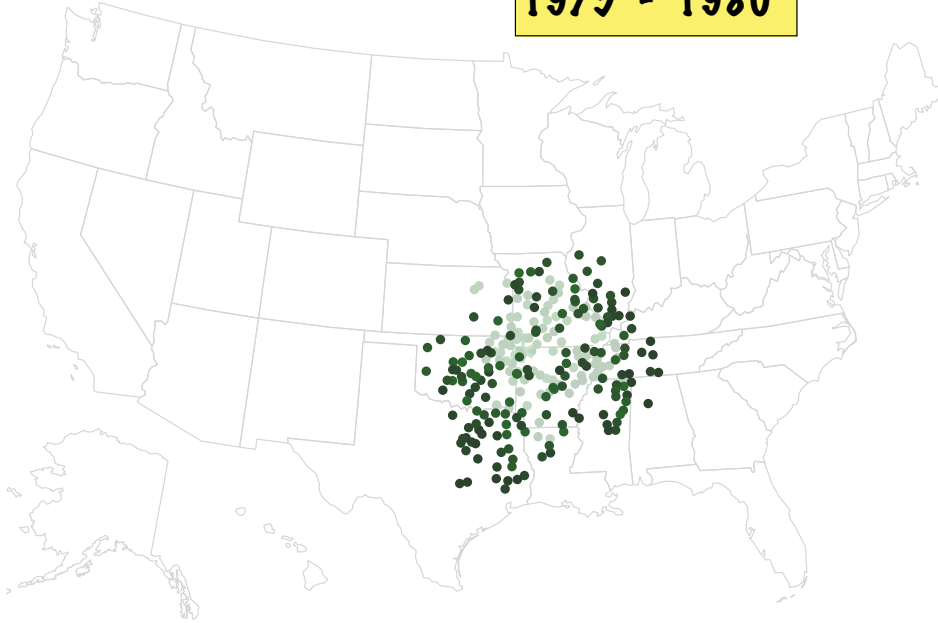
1970 - 1975



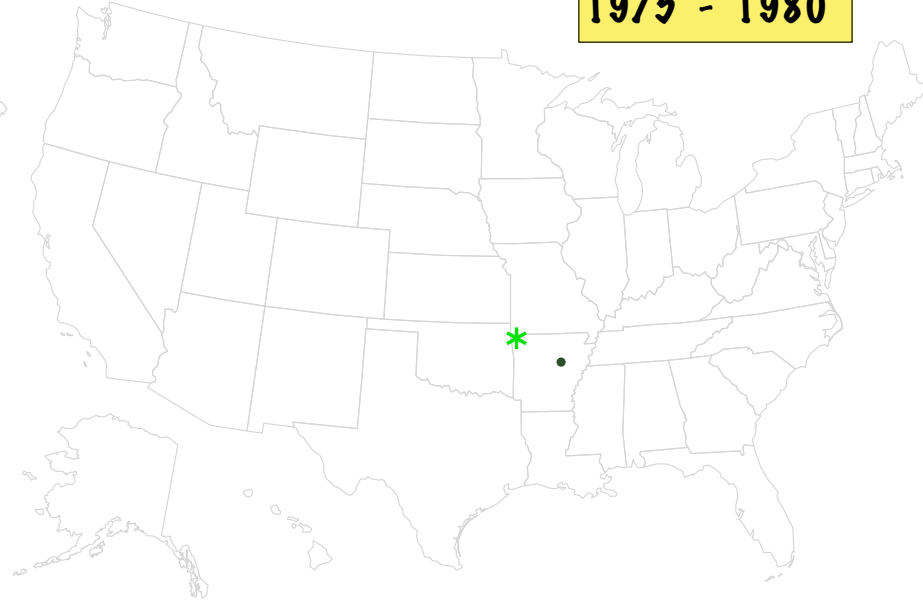
- Store Openings

- Distribution Centers

1975 - 1980

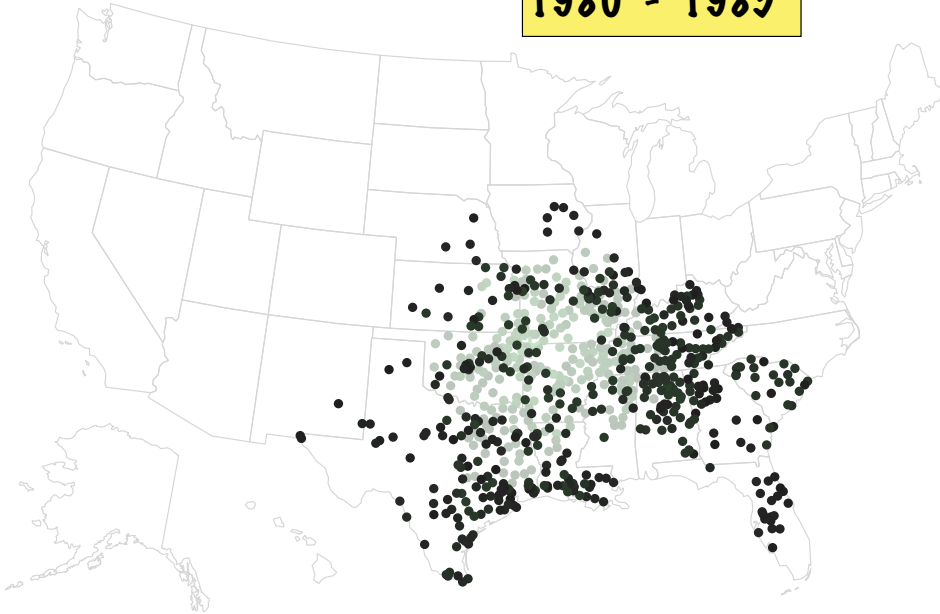


1975 - 1980



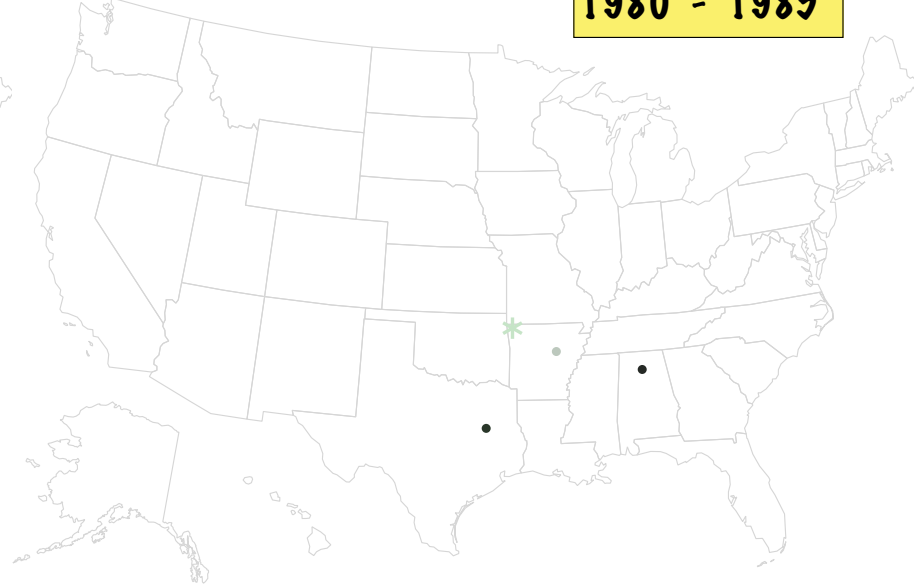
- Store Openings

1980 - 1985



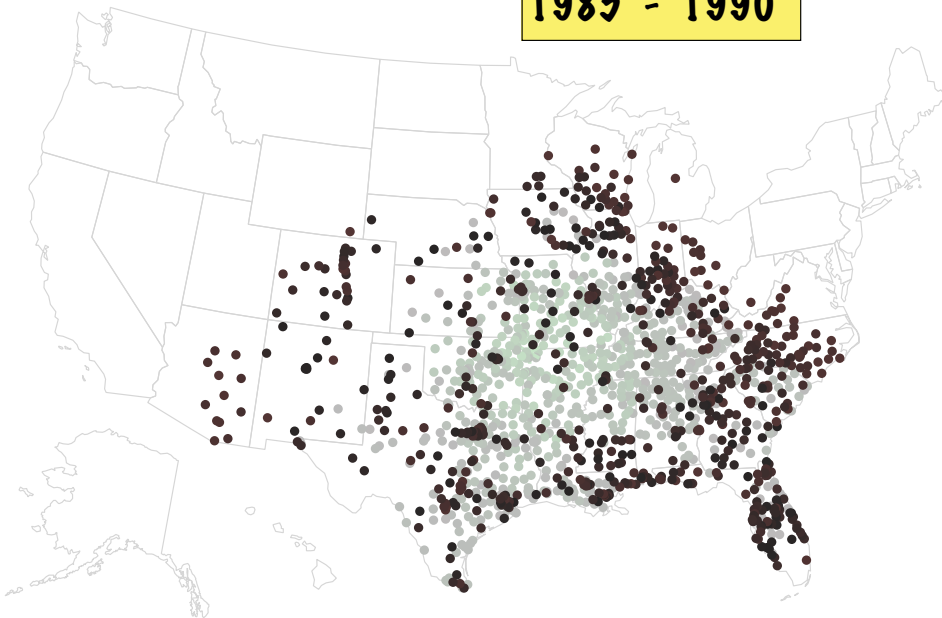
- Distribution Centers

1980 - 1985



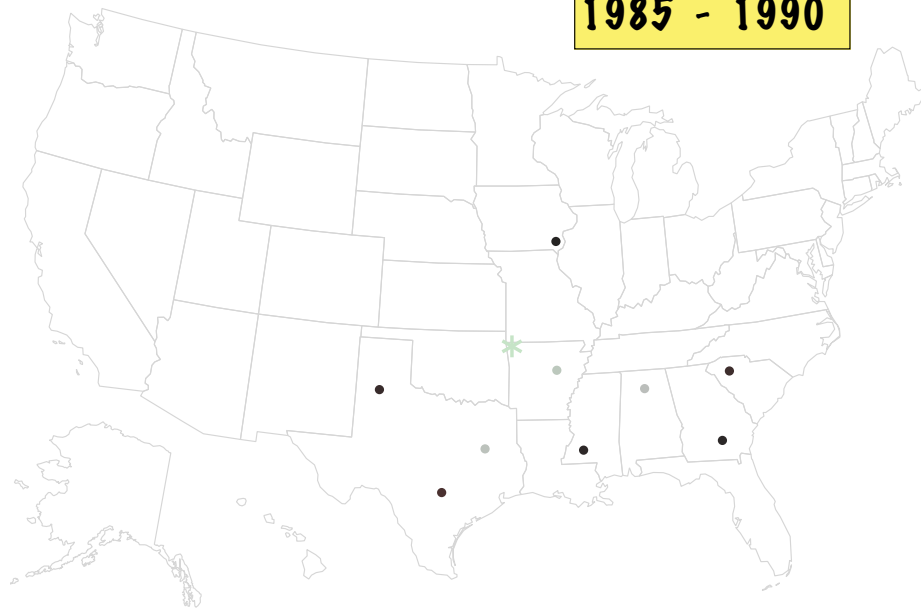
- Store Openings

1985 - 1990



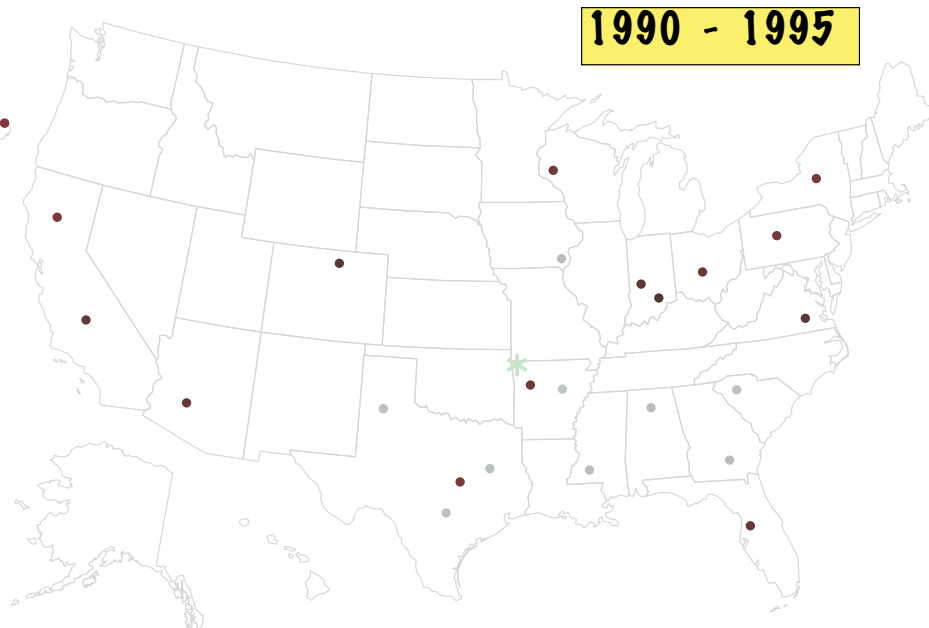
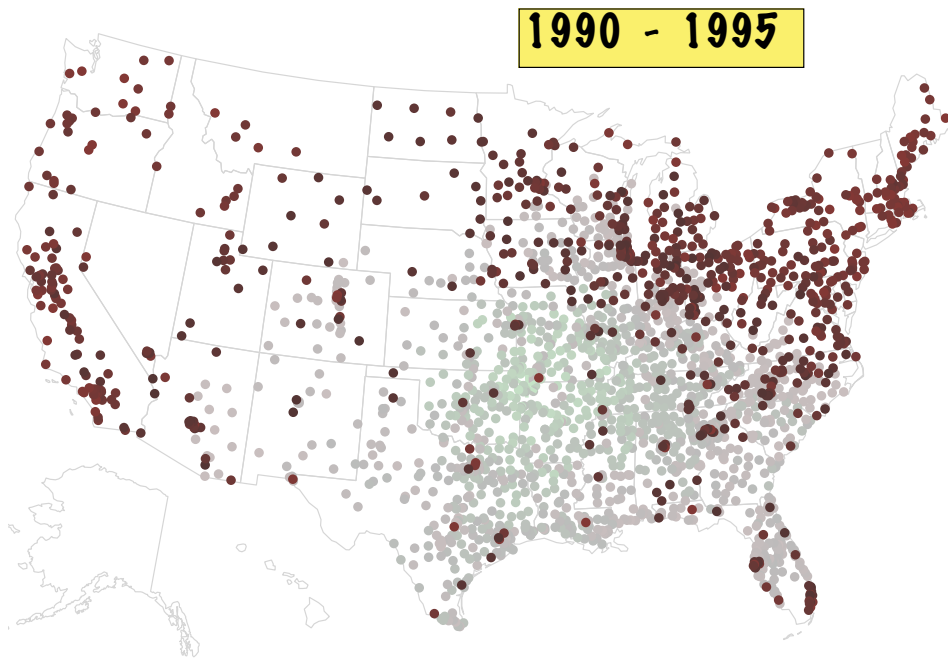
- Distribution Centers

1985 - 1990



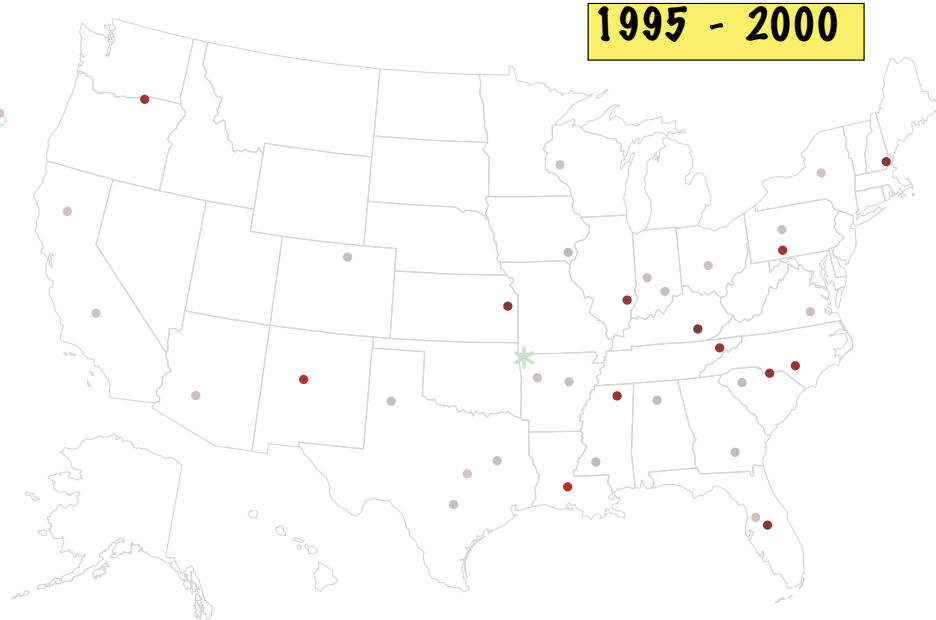
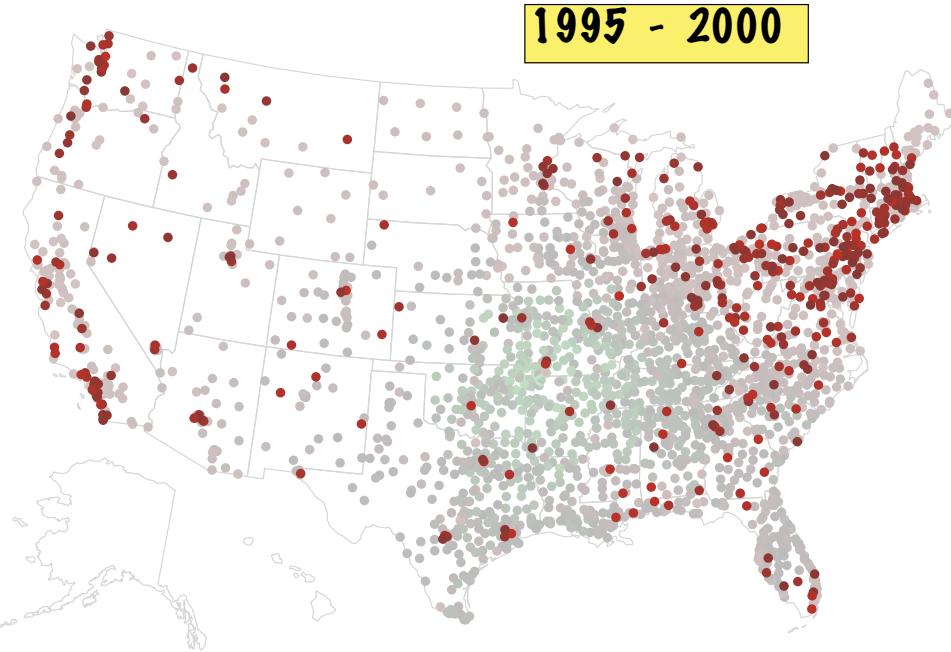
- Store Openings

- Distribution Centers



- Store Openings

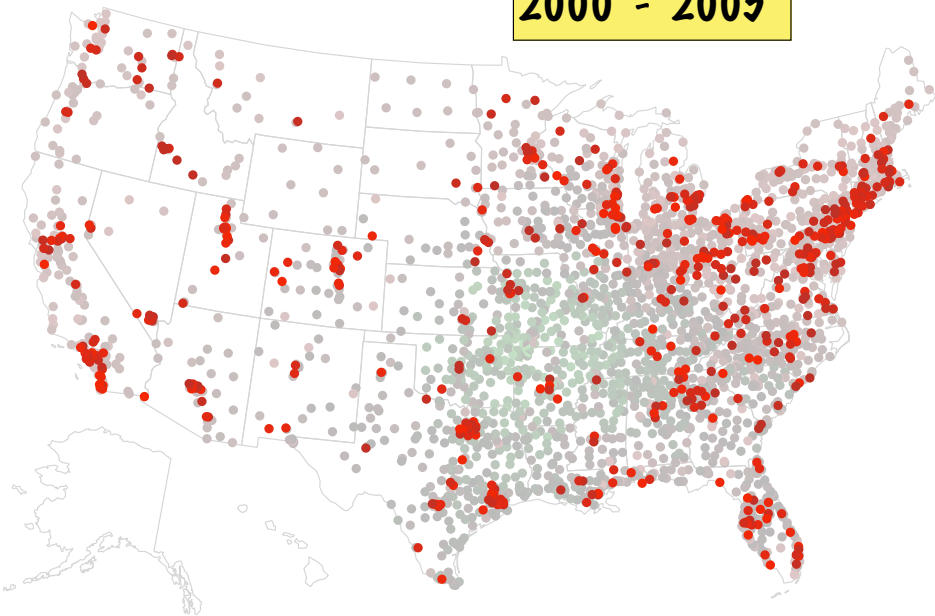
- Distribution Centers



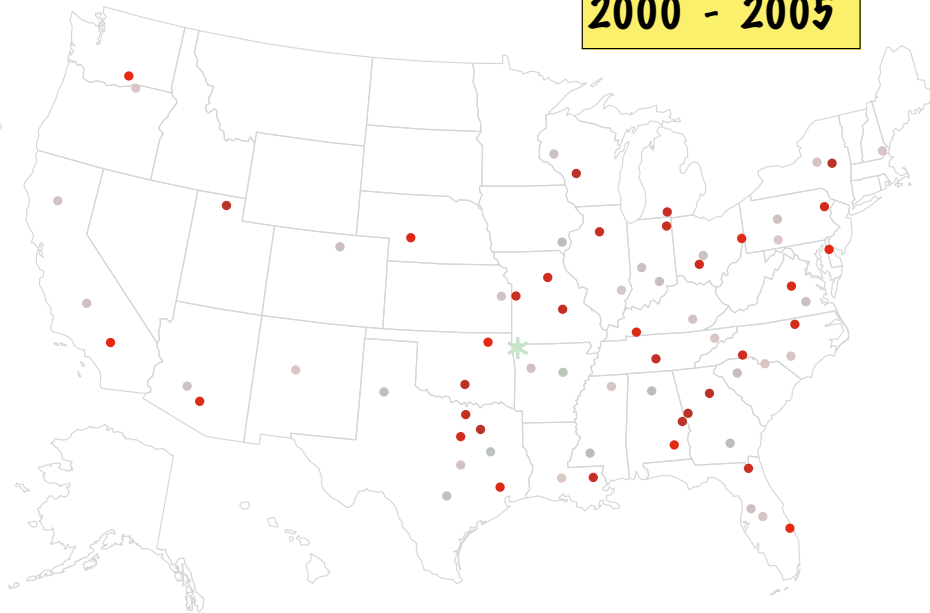


- Store Openings
- Distribution Centers

2000 - 2005

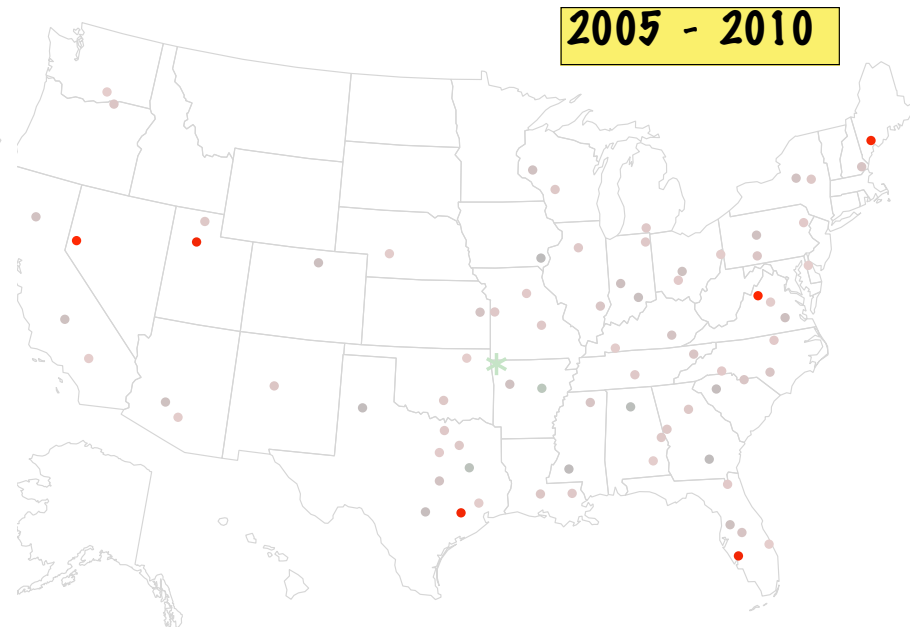
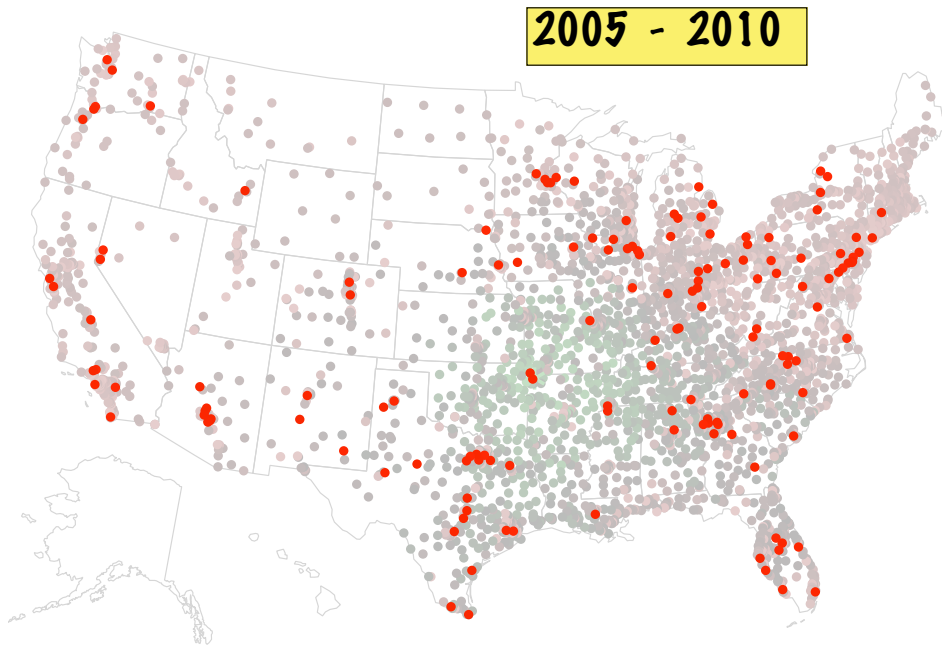


2000 - 2005



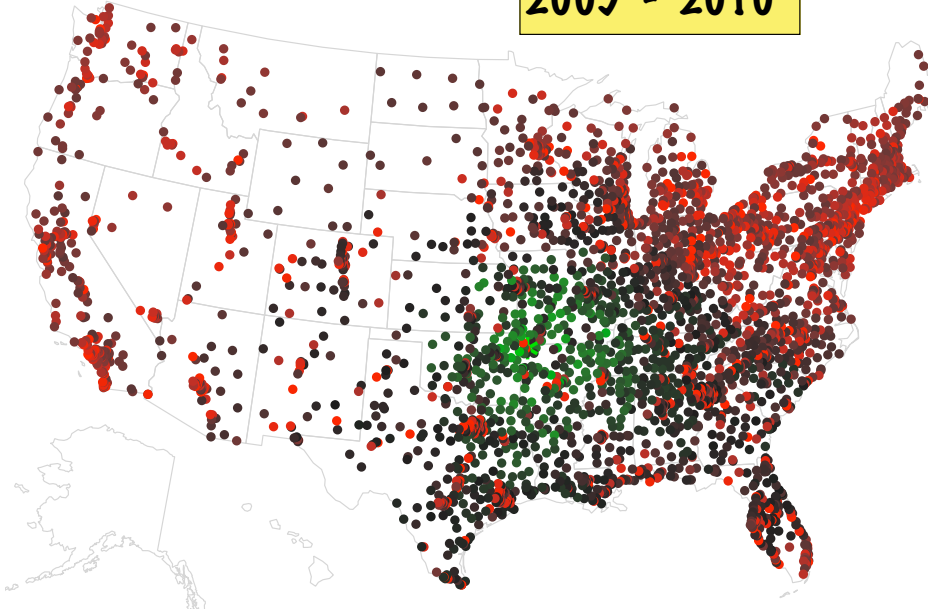
- Store Openings

- Distribution Centers

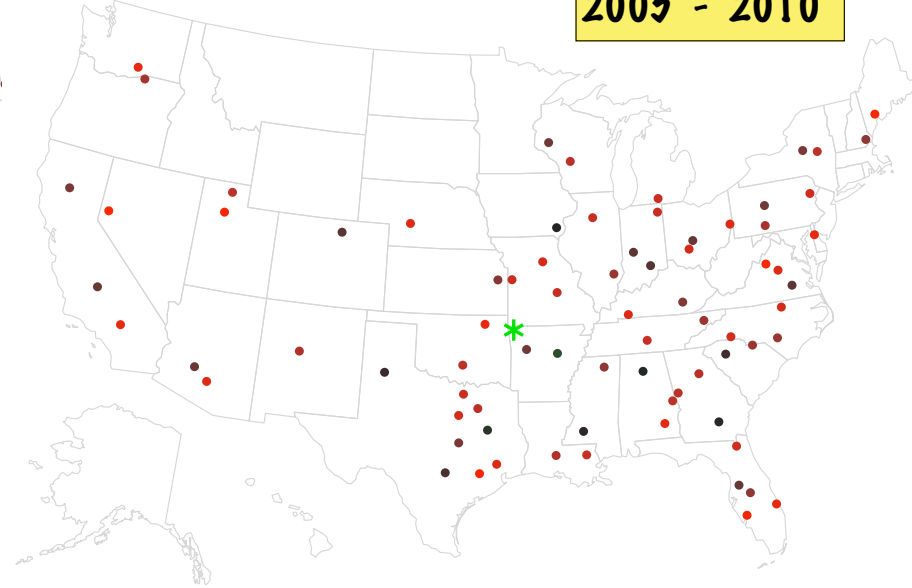


- Store Openings
- Distribution Centers

2005 - 2010

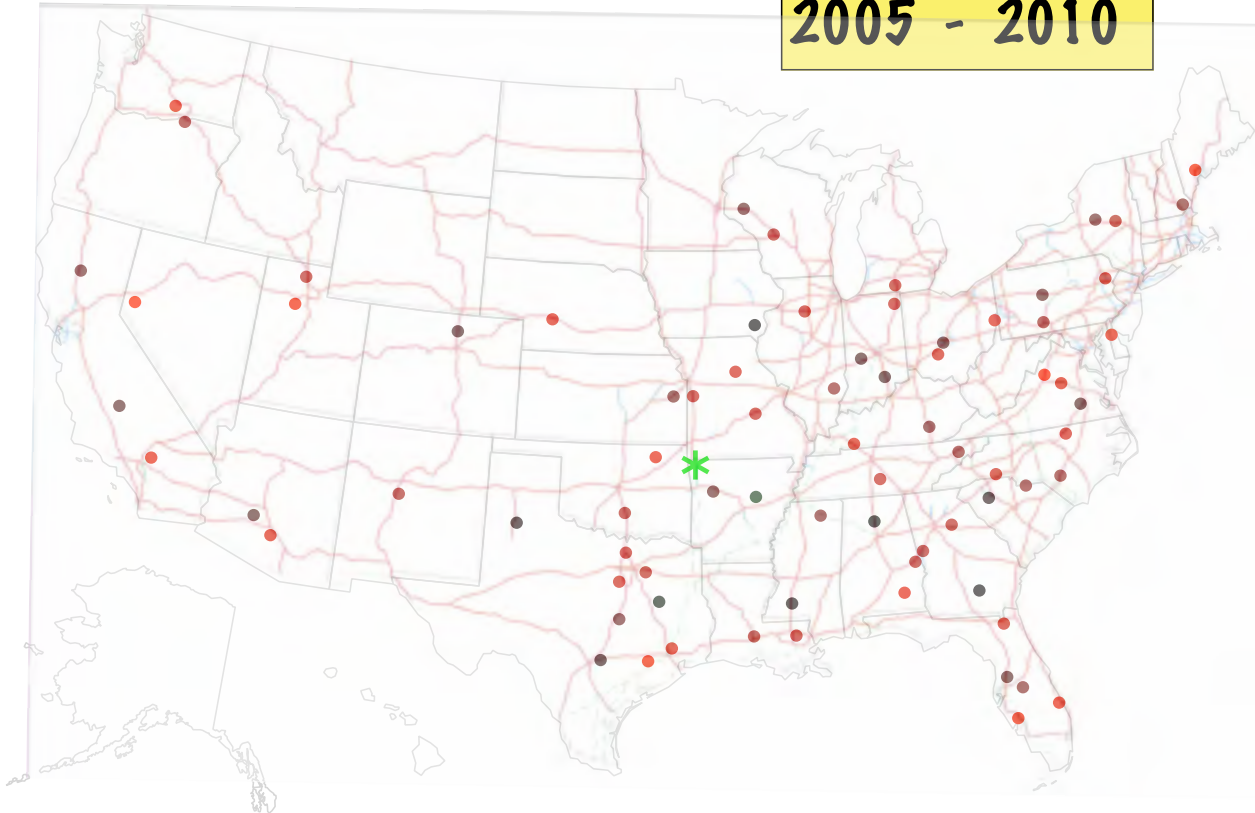


2005 - 2010



# Distribution Centers... are on Interstate near Junctions

2005 - 2010



**WHAT IMPACT DID 'WALMART' STYLE RETAIL  
HAVE ON MFG'S?**

POSTED ON [AUGUST 14, 2015](#) BY [LIMA NEWS](#)

# P&G expanding, to hire in Lima

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BUSINESS, NEWS, TOP STORIES

By Danae King - [dking@civitasmedia.com](mailto:dking@civitasmedia.com)

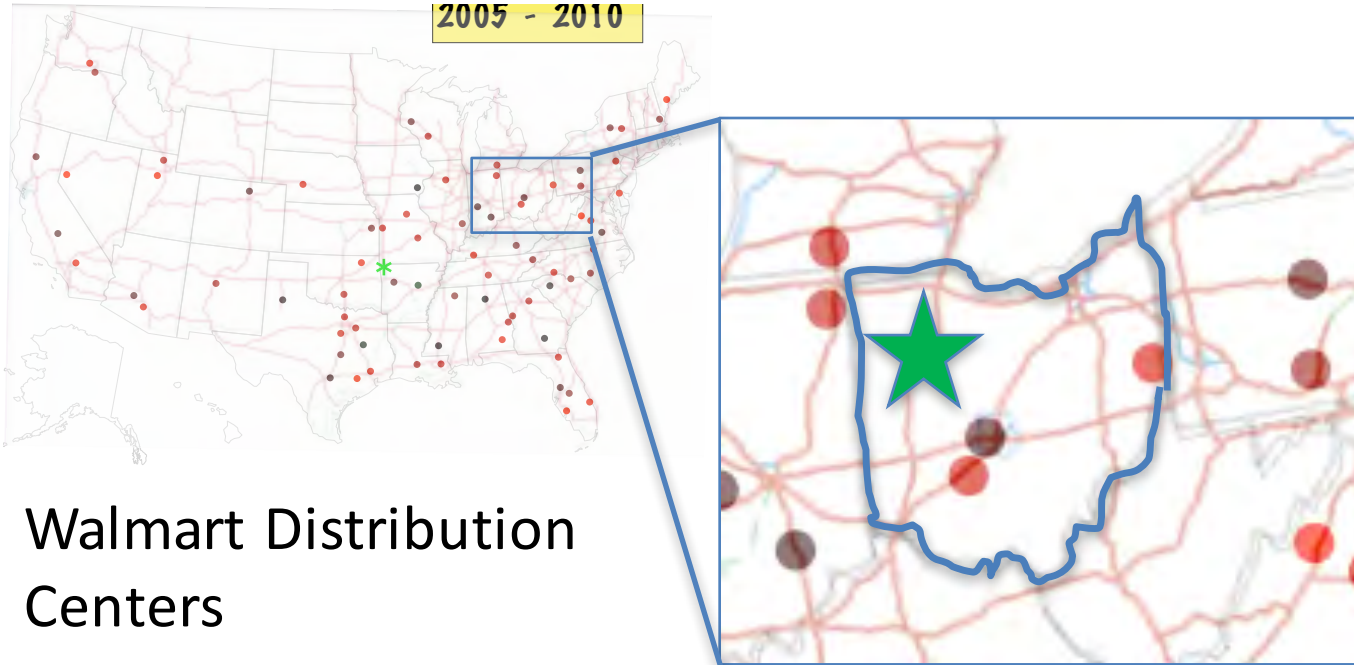
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LIMA — Procter & Gamble is investing \$6 million in its Lima fabric care facility and plans to hire more employees.

The company, headquartered in Cincinnati, recently started an expansion on Building 11 on its property and plans to complete it this fall.

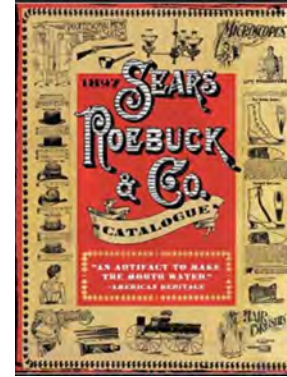
# Where is Lima, OH?





## Back to Retail... Remember Sears?

Sears was the largest retailer in the United States until October 1989, when it was surpassed by [Walmart](#).<sup>[3]</sup>



1897



# What's next?

Another Unintended  
Consequence  
Of a Military  
Decision...



The Internet  
& On-line retail

**Jeff Bezos**



Bezos at the ENCORE awards in 2011

# WHAT WILL BE THE IMPACT ON MANUFACTURING?

Who REALLY KNOWS?... But 'time to fulfill'  
will be more important than shipping costs.

**TIME ... WILL MEAN 'LOCAL' MANUFACTURING**

**'LOCAL' MANUFACTURING WILL BE  
'DOWNSCALED'...BUT NOT MORE EXPENSIVE**

# Can Manufacturers survive these disruptions?

## Yes and No

- No... If you make the wrong product
  - if you are selling ‘candles for light’, better learn to make soap if someone else finds Oil in the ground...or uses electricity.
  - If you cut winter ice out of the river to ‘make cold’...refrigeration will obsolete you
  - If you use a wet film to capture images... digital capture will obsolete you.
- Yes... if HOW you make it can be improved at a faster pace than anyone else.

# U.S. Manufacturers must Innovate or Diminish

- It is NOT just about regulations
- It is NOT just about cheap labor (e.g. offshore)
- It is about INNOVATING HOW we make things... NOT just WHAT we make.
- INNOVATING MANUFACTURING at SCALE is too expensive to GUESS AND TEST.

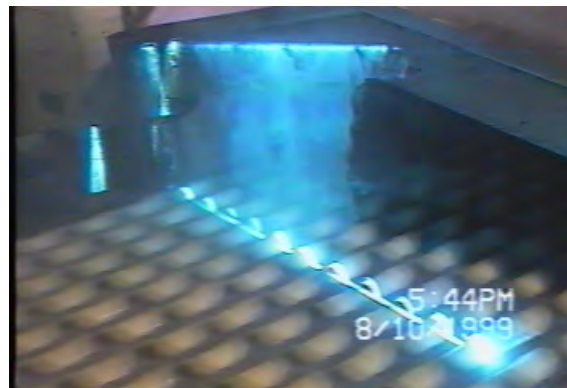
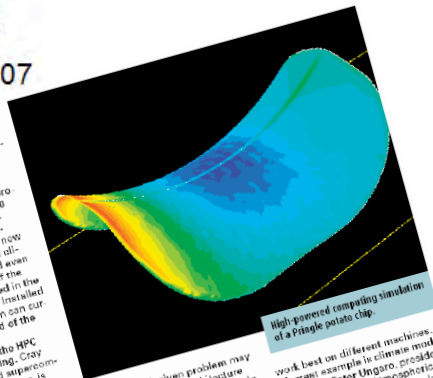


And that Innovation extended to everything ... not just what we made... but how we made it.

# **P&G'S MANTRA... 'INNOVATION IS OUR LIFEBLOOD'**

# FORTUNE

August 20, 2007



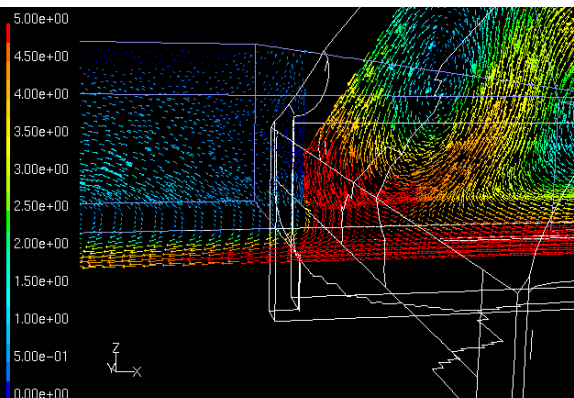
...one issue the m-  
community is addressing. Cray  
the Seattle-based supercom-  
puter giant built Jaguar, is  
working to solve another prob-  
lem: flexibility. Today's machines  
typically use one of four processor  
architectures: in scalar, vector,  
multithreading, and attached co-

## WHY HPC MATTERS

In the Study of U.S. Industrial MNCs sponsored by the Council on Corporate Issues, IDC asked 33 corporate subsidiaries, petroleum, electronics, pharmaceutical, life sciences, software, financial services, transportation, logistics, and entertainment companies in the U.S. where they'd be if they didn't have access to high-performance computing. Their replies:

work best on different machines. "A great example is climate modeling," says Peter Ungaro, president and CEO of Gray. "Atmospheric modeling works well on a scalar computer, while ocean modeling works well on a vector machine. We are looking for a single computer architecture that can efficiently run a wide range of applications."

# How long does it Take to make a **Billion** Pringles?



Velocity Vectors Colored By Velocity Magnitude (m/s) (Time=1.8410e+01) Mar 16, 2000  
FLUENT 5.3 (3d, segregated, rngke, unsteady)

May 2013



How to Make the Next Big Thing

# Assembled in Code

Digital simulations have become so powerful that companies send their products through the wringer—sometimes literally—before ever building a prototype

By James D. Myers

WHEN THOMAS EDISON invented a practical electric lightbulb more than 130 years ago, he performed thousands of experiments on prototypes, and we still marvel at his methodical patience today. A modern inventor proposing a similar approach, however, would more likely elicit laughter than praise. Product research and development more and more lives in the realm of bits and bytes, with engineers designing, testing, tweaking and even demonstrating new ideas via computer before any physical version exists.

Powerful computer servers performing highly calculations



**DIGITAL WASH:** P&G used intensive simulations to ensure that Tide Pods would behave properly inside the chaotic environment of a washing machine.

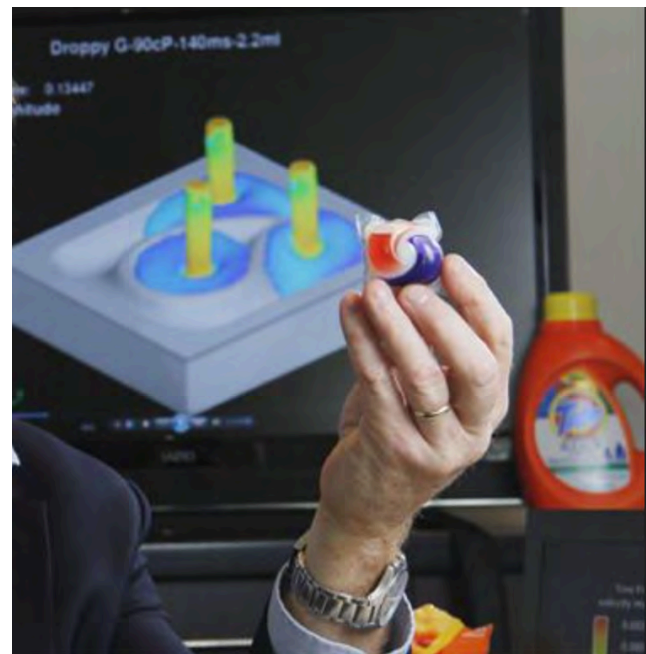
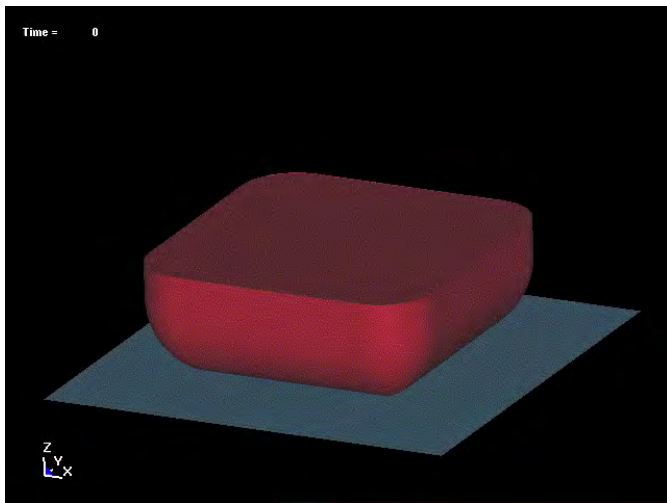
Computer-drawn models and complex digital simulations increasingly dictate what those items look like, how they are made, what they are made of and how they will perform together. Driven by Moore's law, which holds that computer processing power doubles roughly every 18 months, HPC capabilities should advance another 1,000-fold in the coming years. It is no surprise, then, that in the

# Scientific American May 2013

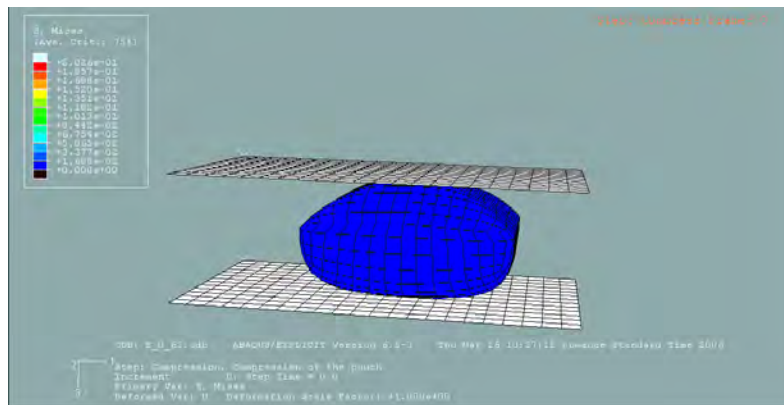
“Digital simulation have become so powerful that companies send their products through the wringer—sometimes literally --- before ever building a prototype”

James D. Meyers  
May 2013 Scientific American

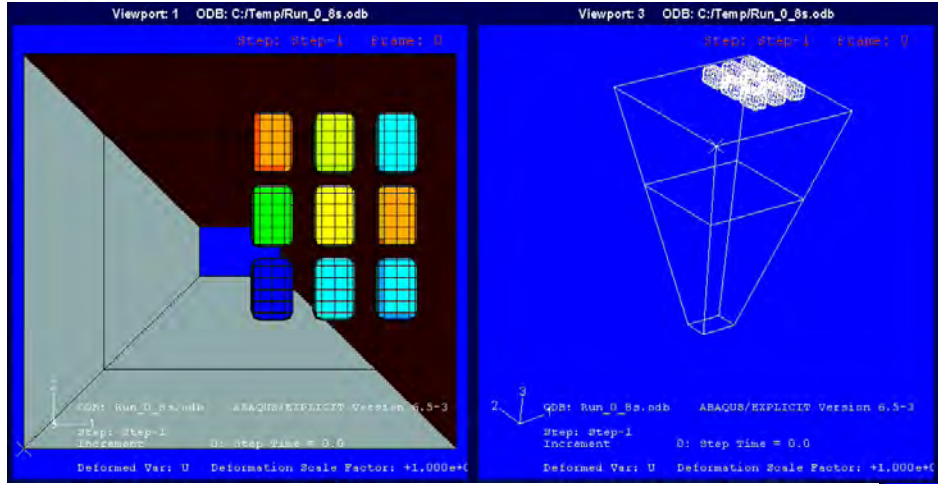
# Making Tide PODs



Filling & making the POD  
To never leak...

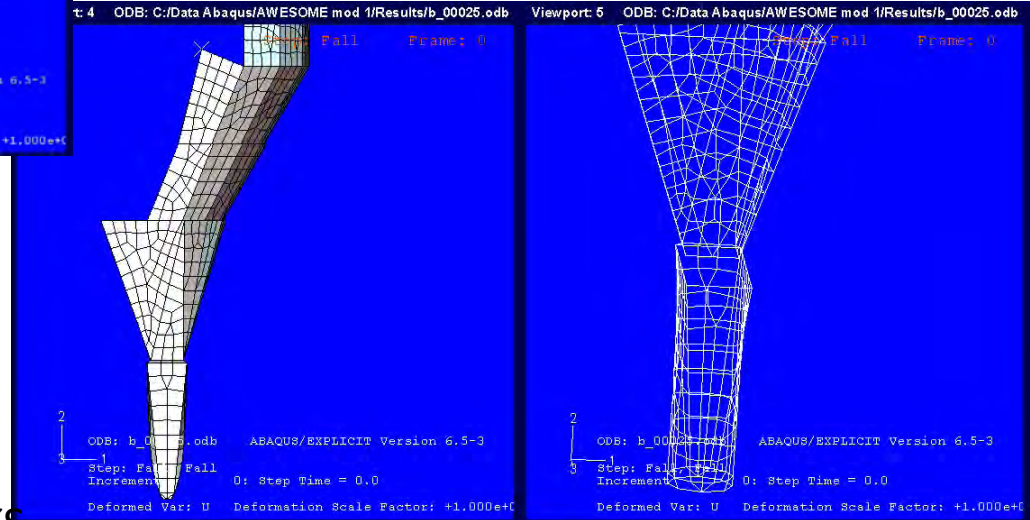






DOES NOT WORK

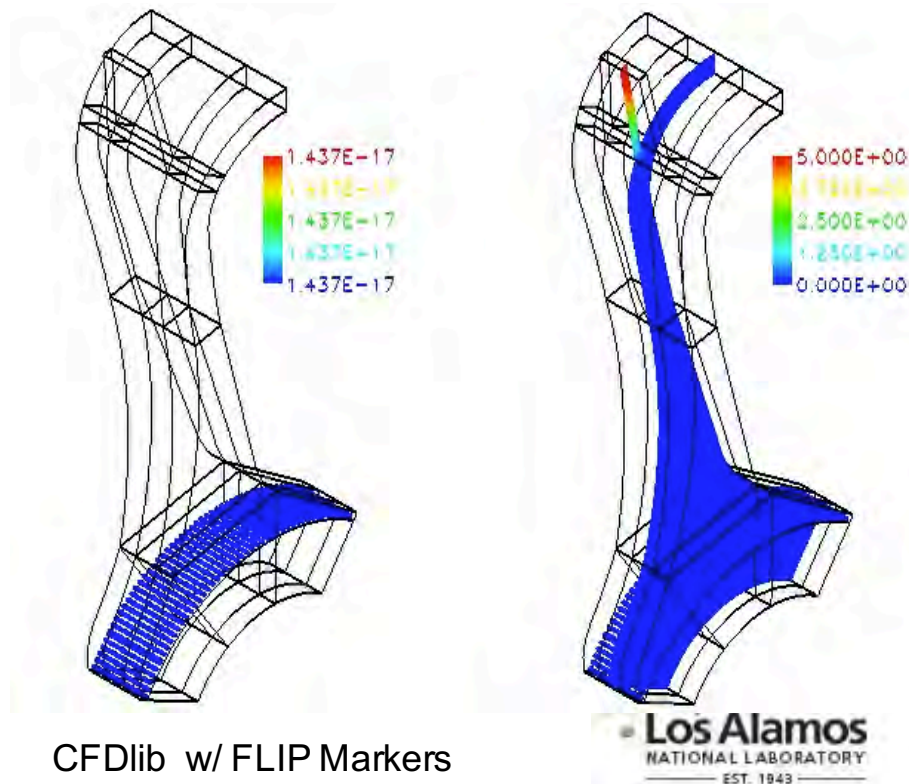
Something as simple as putting pods into a tub ... needed simulation



WORKS

# Fluids: Making Absorbent Diapers

Multi-Phase  
Turbulence...  
w/ Material  
Accumulation  
At the  
Boundaries



CFDlib w/ FLIP Markers  
(Bucky Kashiwa)  
@ Los Alamos National Labs





Including some parts of P&G!

# **WHY DOESN'T EVERYONE INNOVATE?**



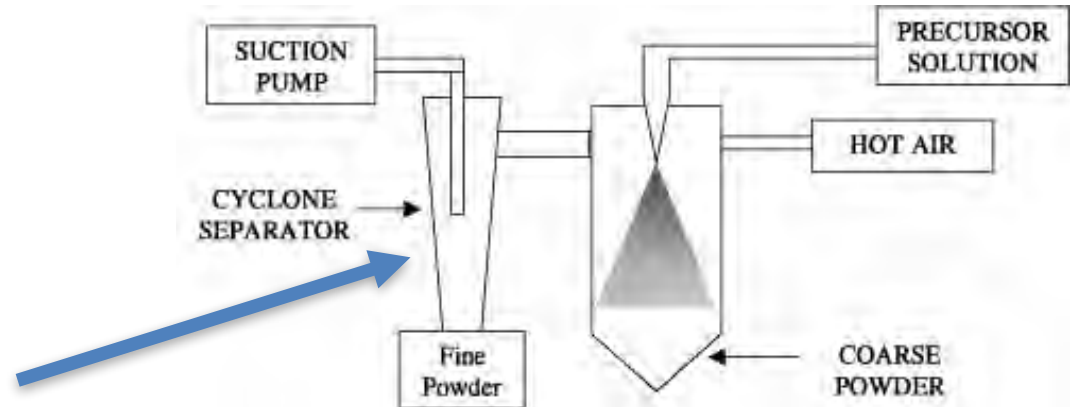
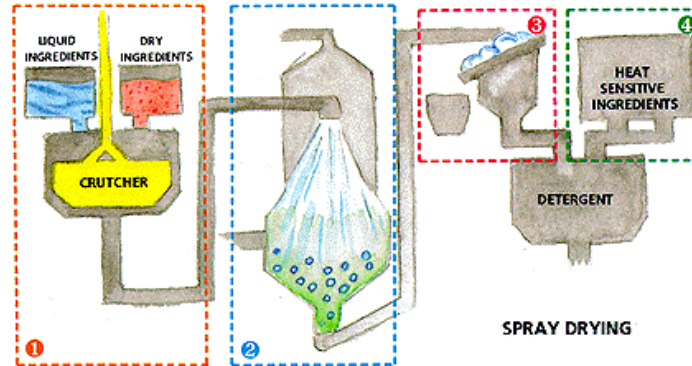
This is especially true for manufacturing at scale

**MOST TIMES, YOU JUST CAN'T TEST**

# 2017 'T.O.M. Client' Case Study: Cyclone Separator for Sticky Dust

- 1) Confirm Pressure Drop
- 2) Assess "Build-up" Risk
  - Inlet Chutes
  - Discharge Throat
- 3) Confirm Separation Efficiency
- Use Literature & Historic Empirical Equations for Existing Evaluation & New Design
- Use CFD to 'test' existing and proposed designs.

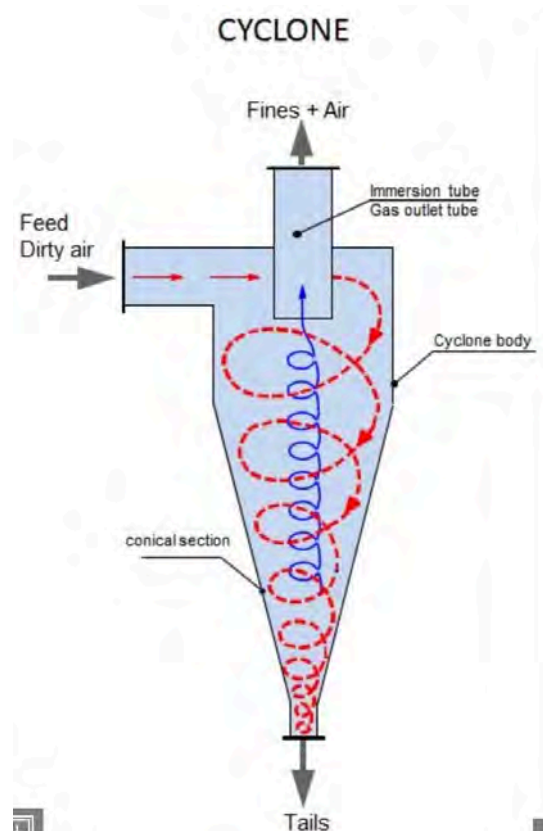
# Cyclones at P&G



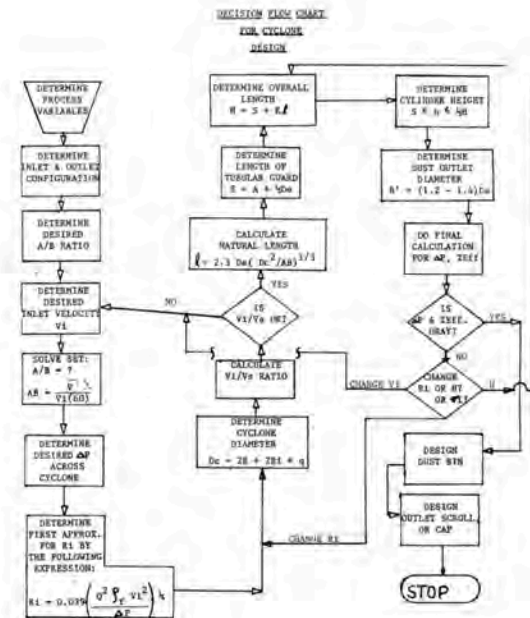
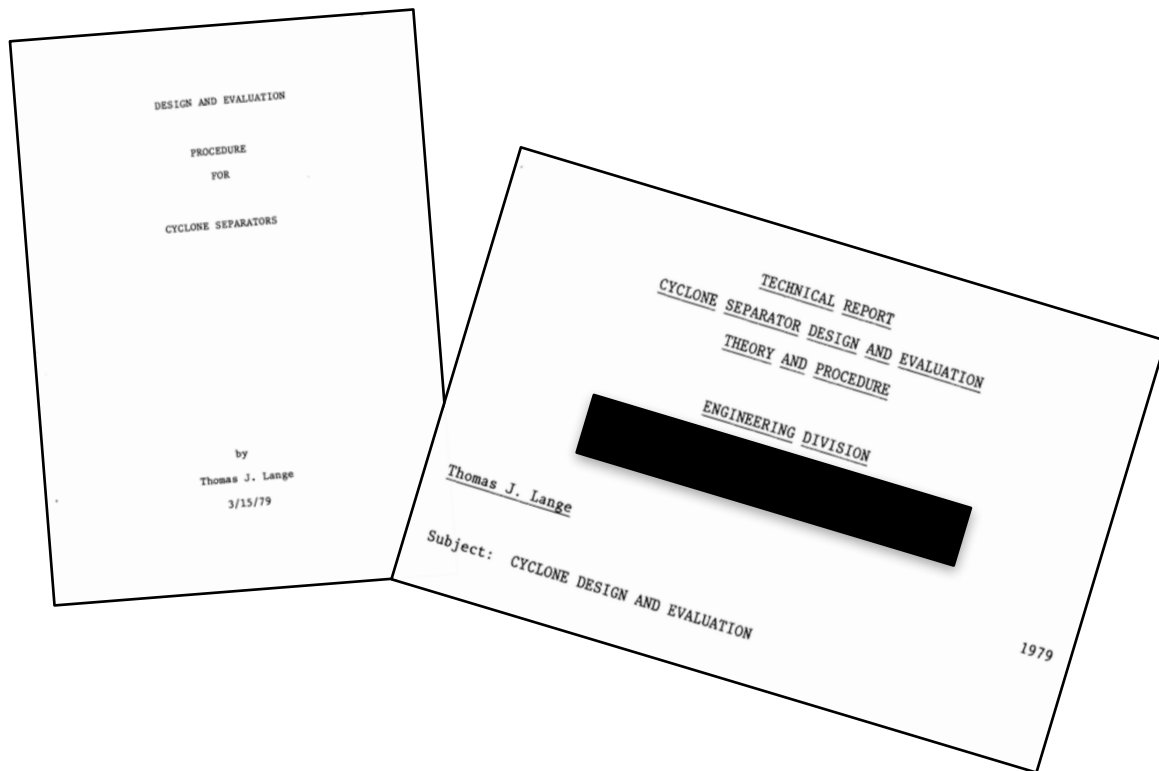
## Images of muschelknautz designing cyclone separators

## Application of Muschelknautz models in design of cyclone

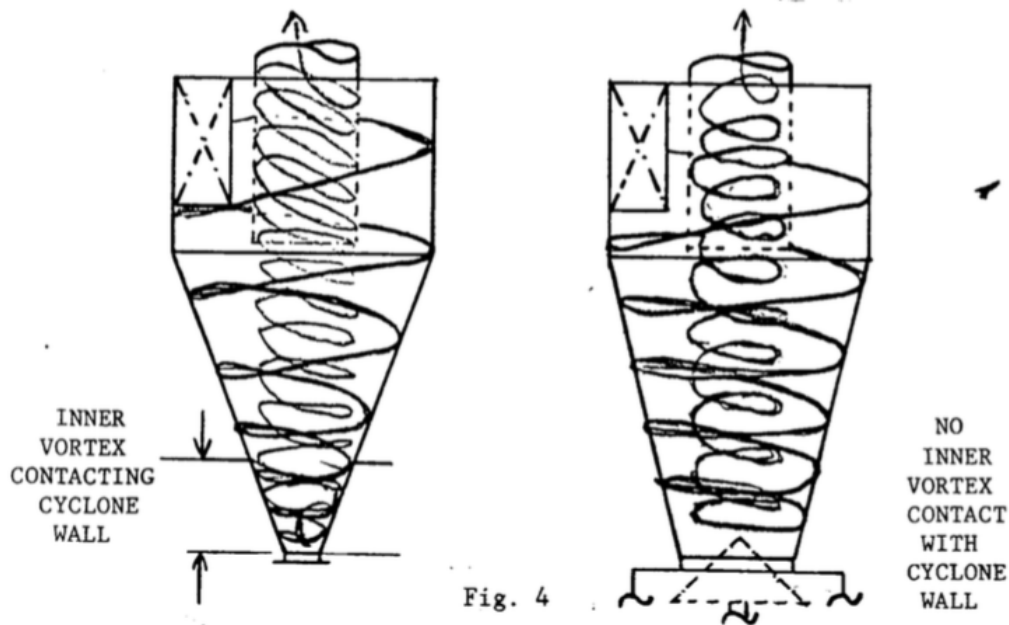
Application of **Muschelknautz** models in **design** of **cyclone** on ... The three-dimensional strongly swirling turbulent flow in a **cyclone separator** with a volute inlet ...



# P&G Design Approach



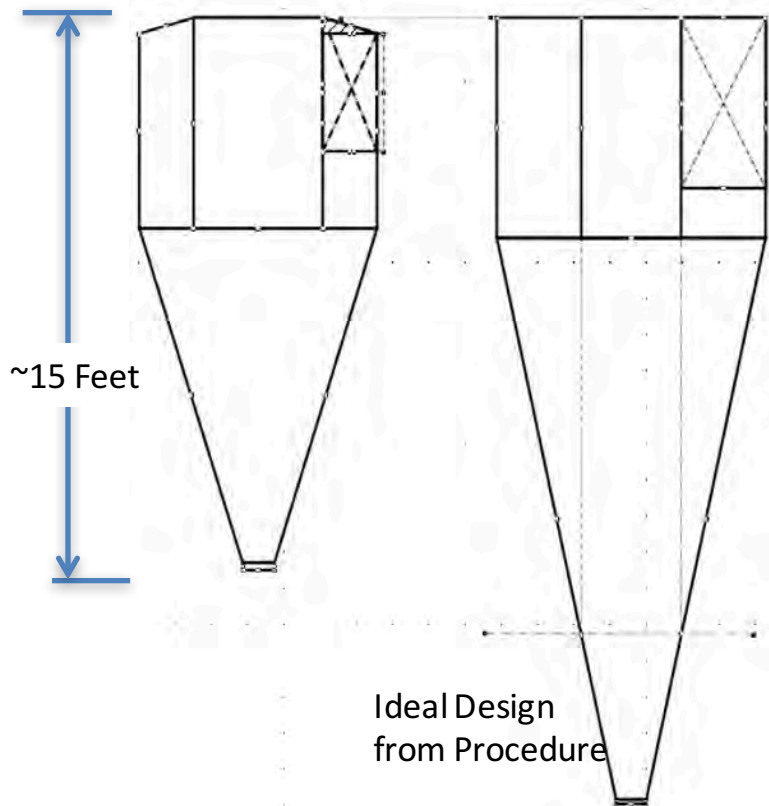
# 1979 Understanding of Vortex & Wall Interference



Inner and Outer Vortex Profile



# Geometry Comparison...Old vs New



Bigger Inlet:  
Bigger Diameter  
Longer Cyclone:

Smaller Tubular Guard:

Lower Pressure Drop?

Higher Separation Efficiency?

# TOTALSIM<sup>US</sup>

[REDACTED]

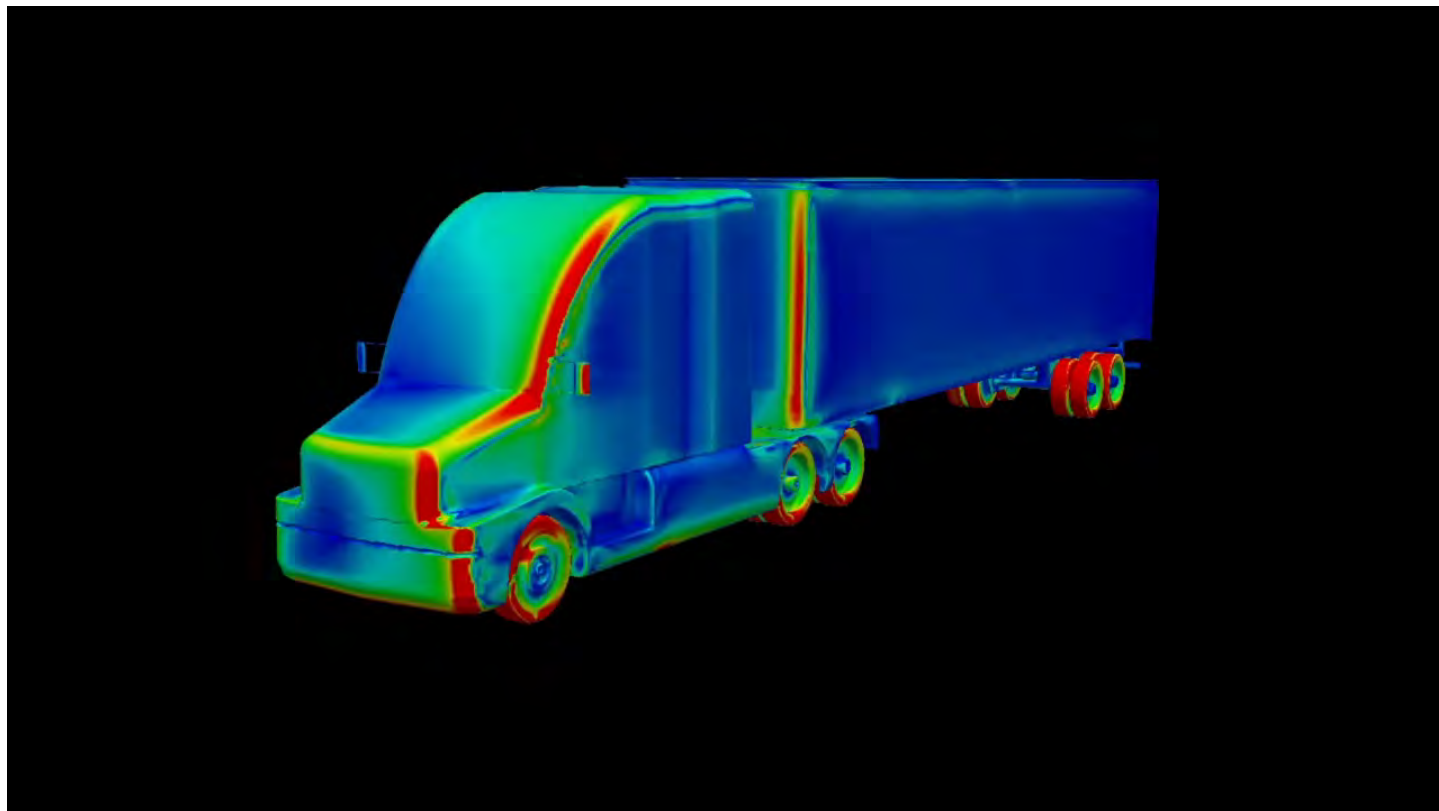
Cyclone separation

Preliminary CFD Analysis


**Presented to Technology Optimization  
& Management**

February 27, 2017

**NOTE: PRELIMINARY RESULTS -- PLEASE DO NOT CIRCULATE**



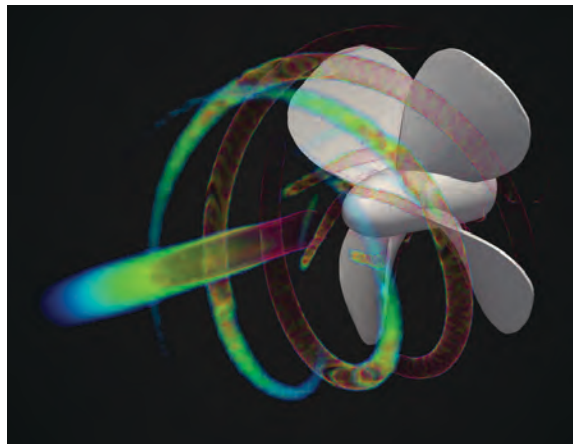
# More 'Apps' from AWESIM Catalog



Fan **SIM**

CFD-based evaluation of fan geometries.

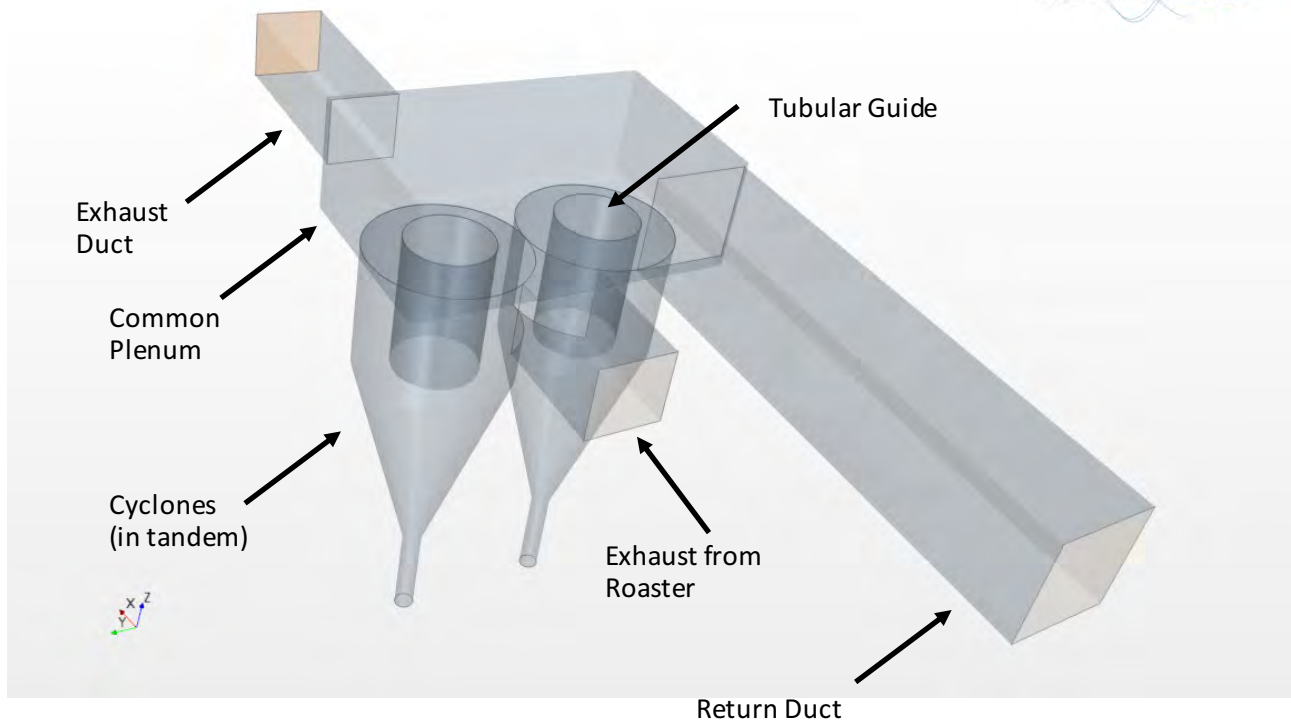
Log In



# Overview

- CFD analyses have been initiated for the baseline, ideal design, and 3Crown (modified baseline) design
- Methods used here consist of primarily steady-state analysis using one of the two turbulence models:
  - Rayleigh Stress Model – calculates the full stress tensor and potentially provides the highest vortex structure resolution but is very difficult to get a converged solution
  - SST k- $\omega$  with curvature correction – an alternative approach to RSM that is more stable and easier to converge but is more highly dissipative due to the way it models turbulent viscosity
- NONE of the solutions are typically what would be classified fully converged but exhibit enough stability in error residuals that some qualitative information might be gained from the PRELIMINARY results presented here

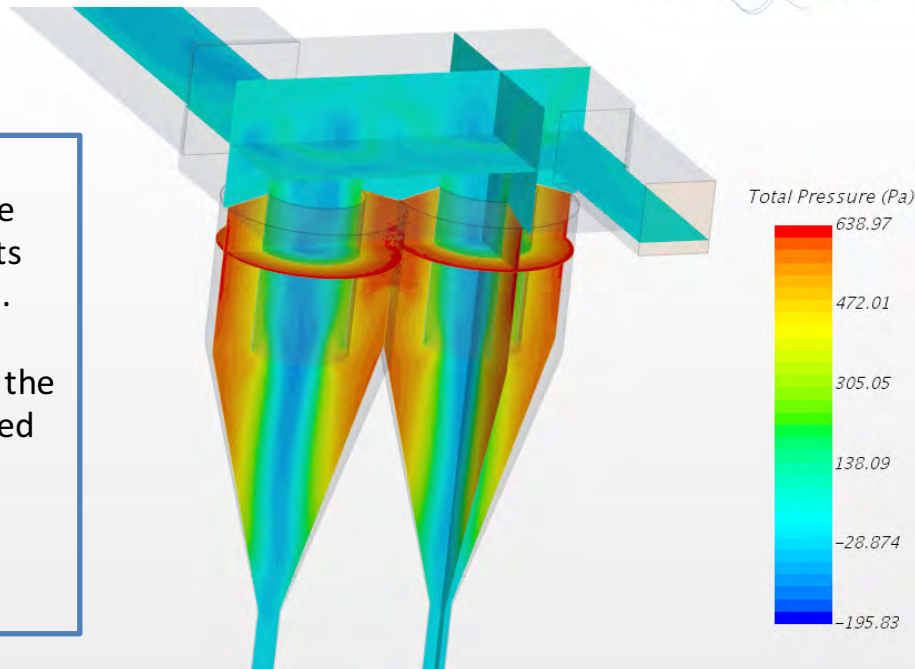
# Baseline Geometry

TOTALSIM<sup>US</sup>

# Baseline Velocity Profiles

TOTALSIM<sup>US</sup>

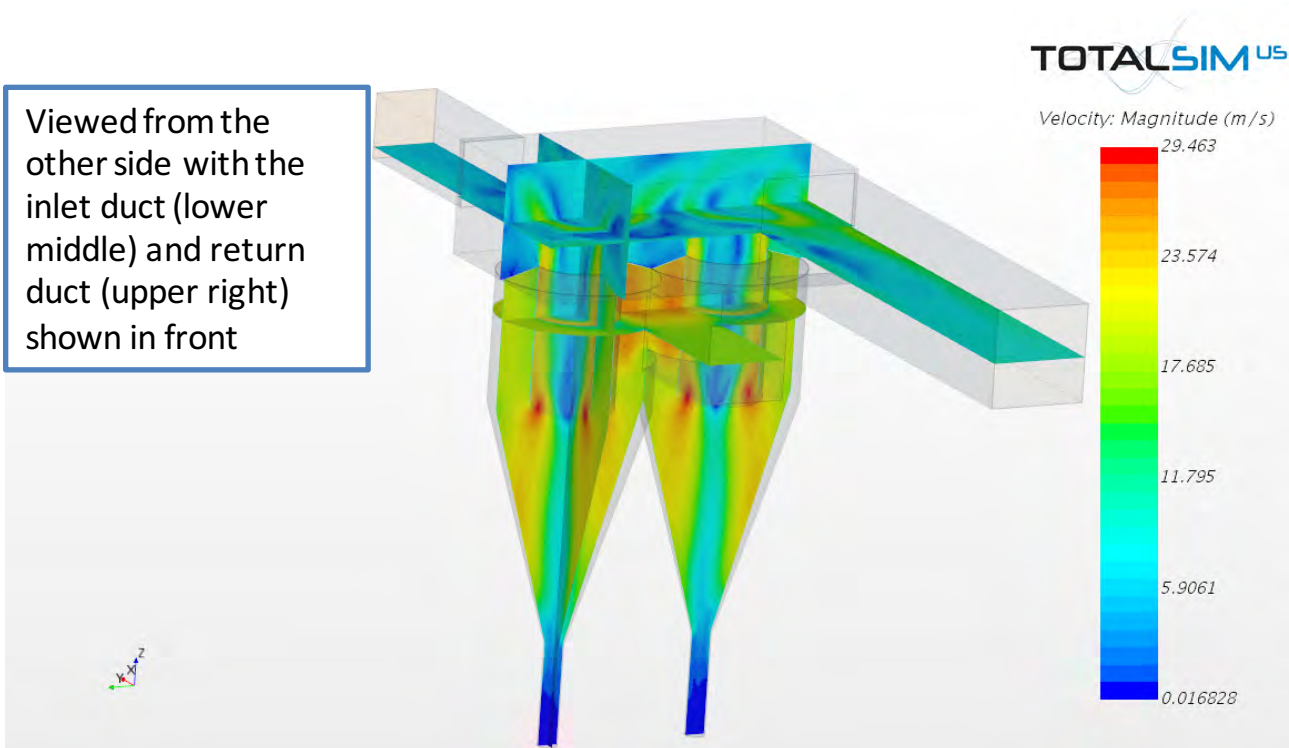
Viewed from the exhaust side with the inlet and return ducts on the opposite side. several transverse planes pass through the domain of the coupled system where plots of velocity magnitude are presented



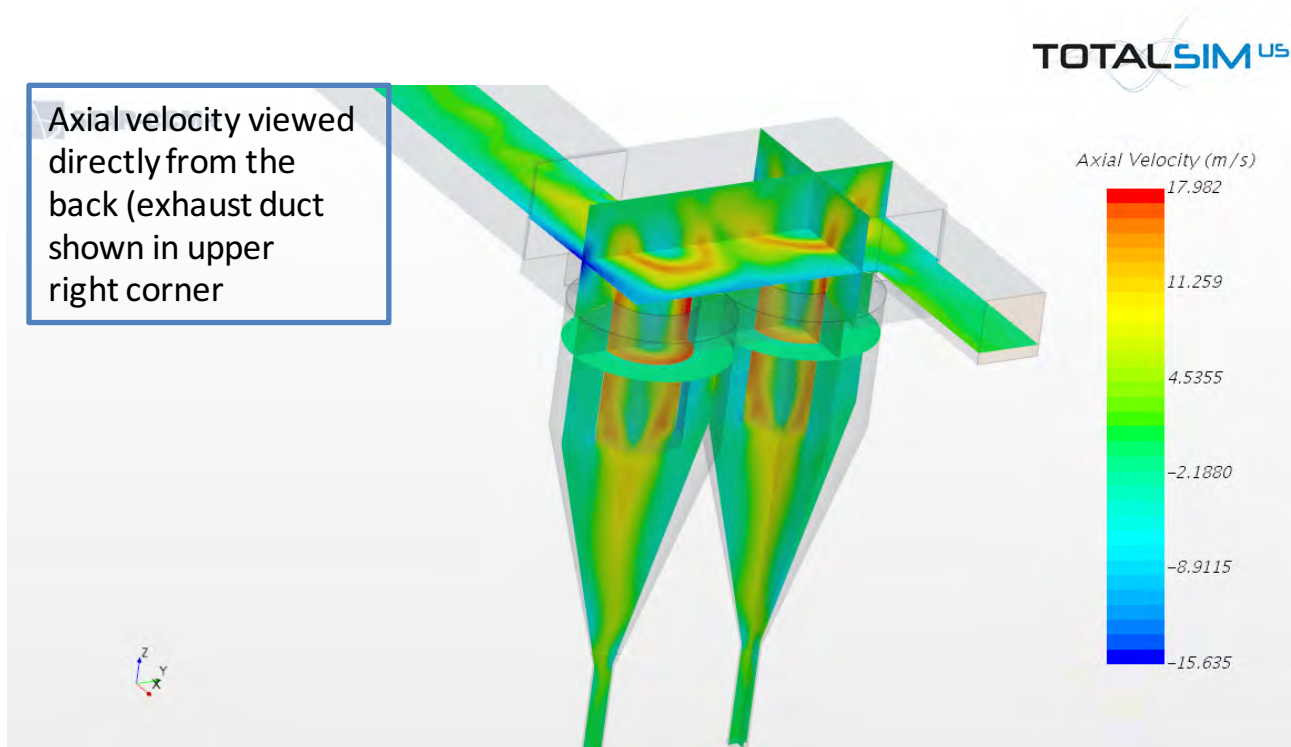


# Existing Velocity Profiles

Viewed from the other side with the inlet duct (lower middle) and return duct (upper right) shown in front



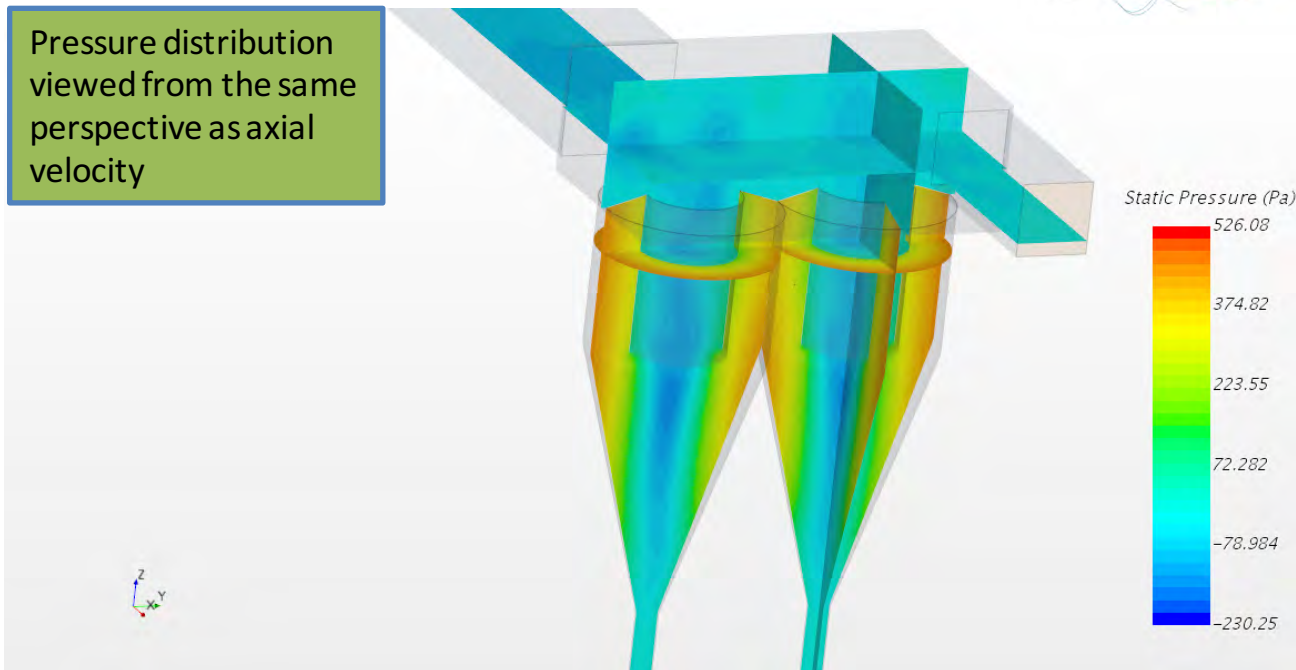
# Baseline Axial Velocity Profiles



# Baseline Pressure Profiles

TOTALSIM<sup>US</sup>

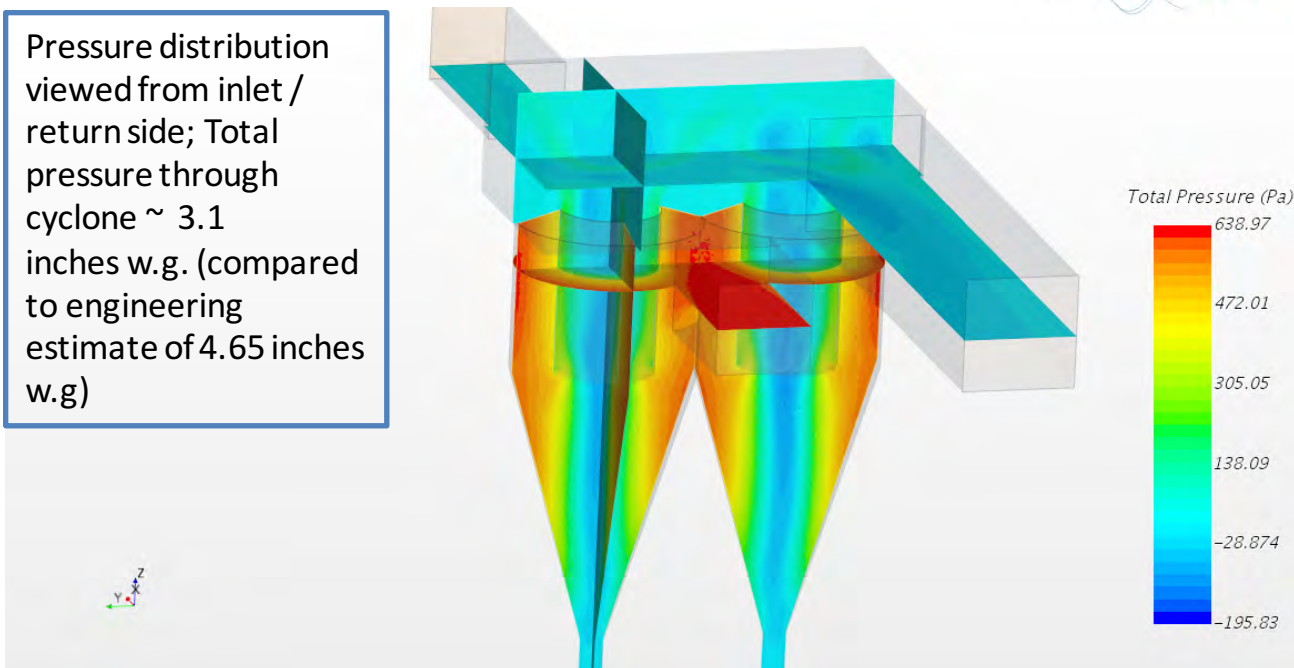
Pressure distribution  
viewed from the same  
perspective as axial  
velocity



# Baseline Pressure Profiles (continued)

TOTALSIM<sup>US</sup>

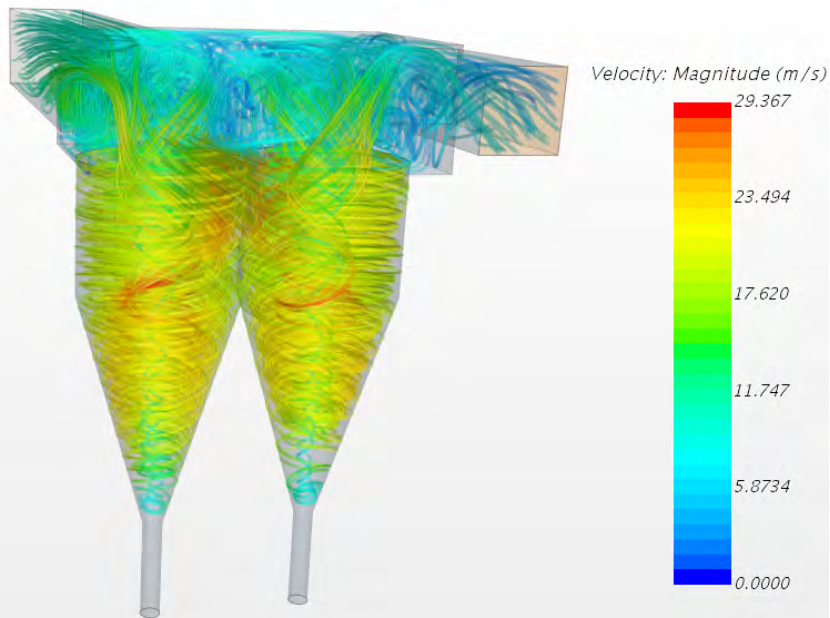
Pressure distribution viewed from inlet / return side; Total pressure through cyclone ~ 3.1 inches w.g. (compared to engineering estimate of 4.65 inches w.g)



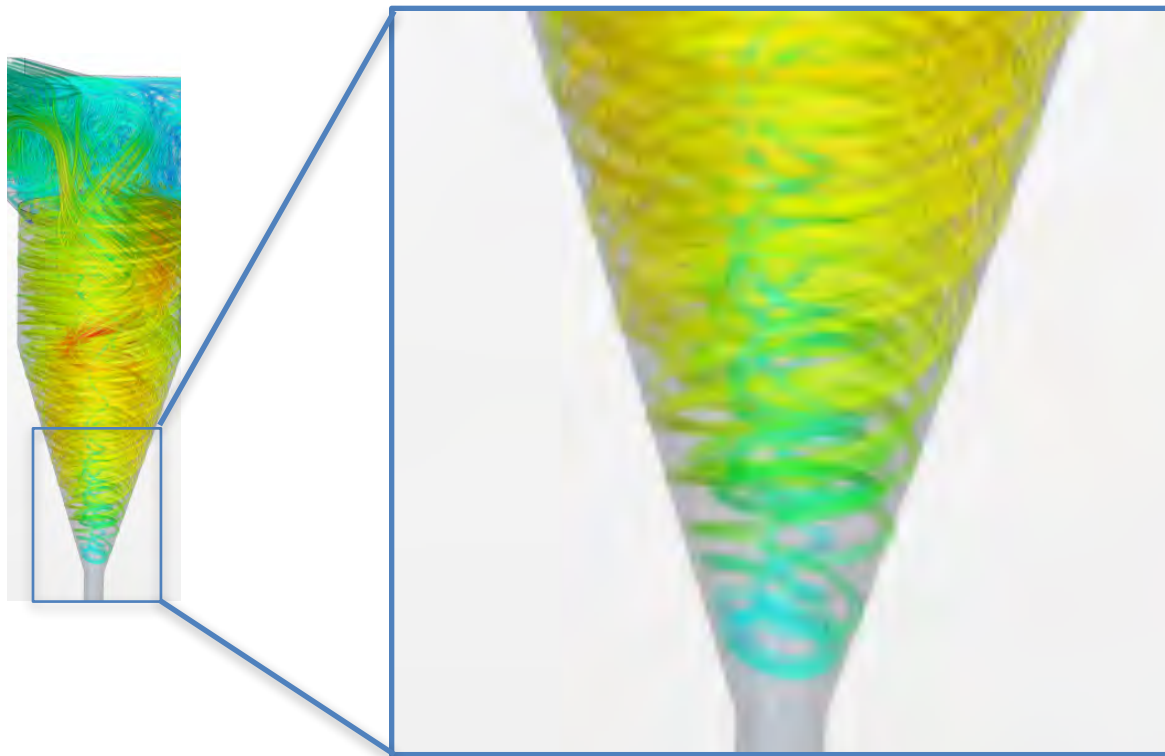
# Existing Flow Streamlines

Sample path lines entering through inlet and discharged through exhaust duct (opposite side) and return duct

TOTALSIM<sup>US</sup>

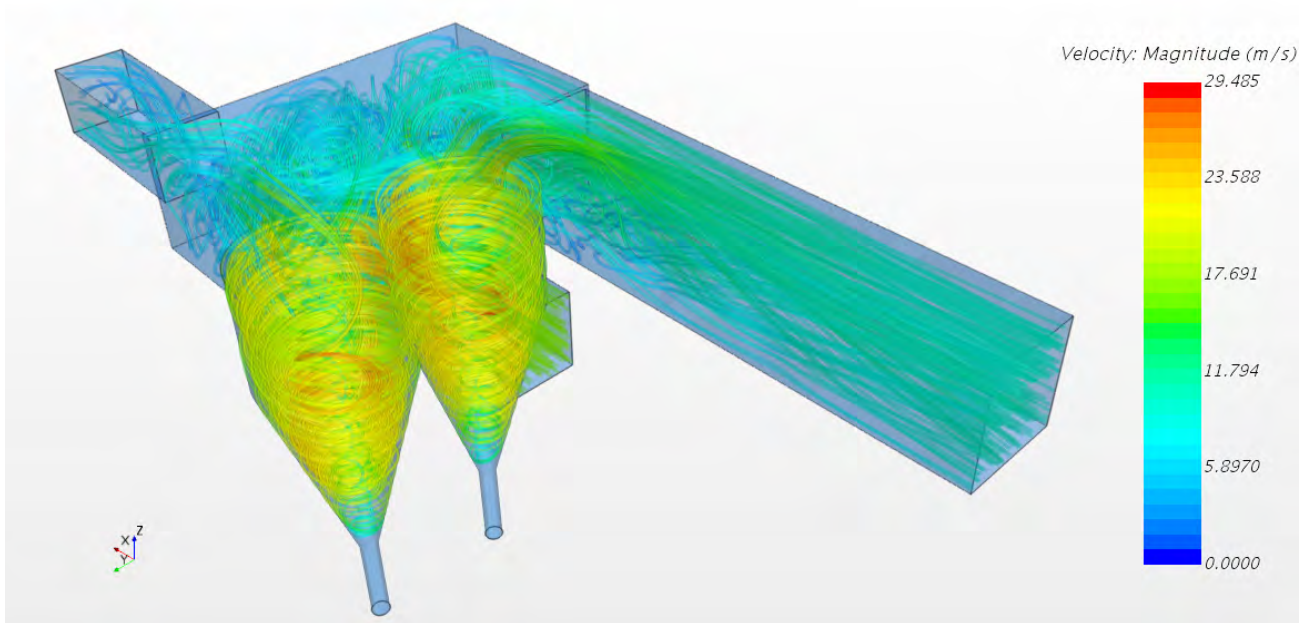


# Vortex Inverts at 'Throat' Wall Contact



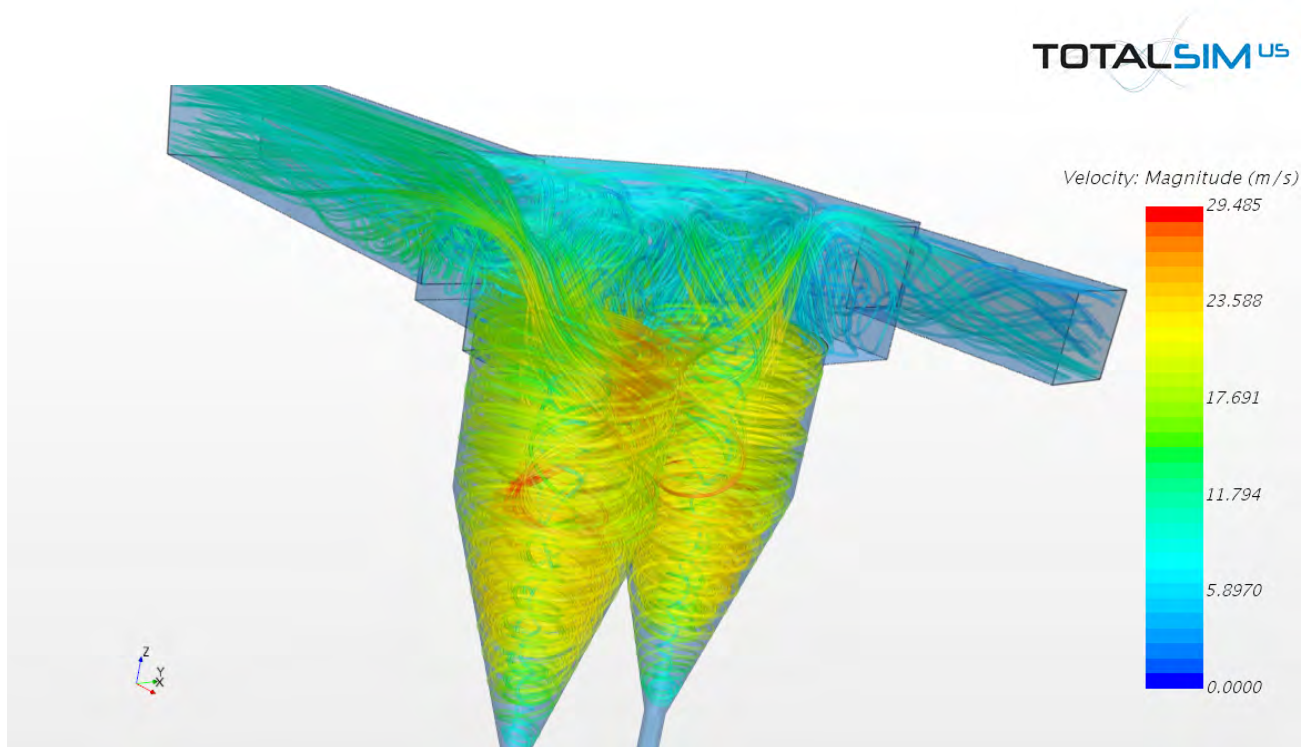


# Baseline Streamlines (inlet/return side)

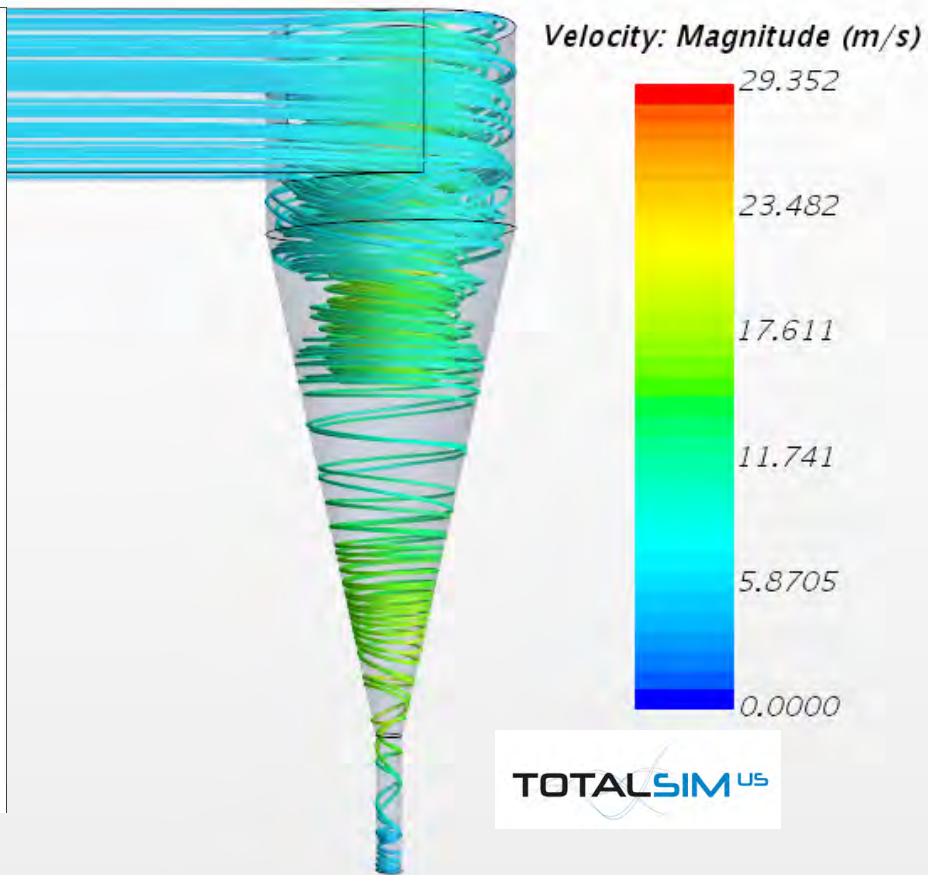
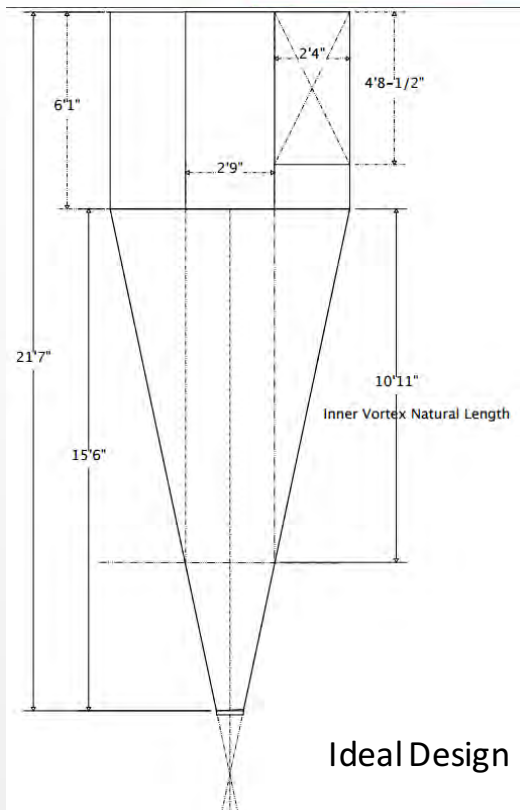
TOTALSIM<sup>US</sup>

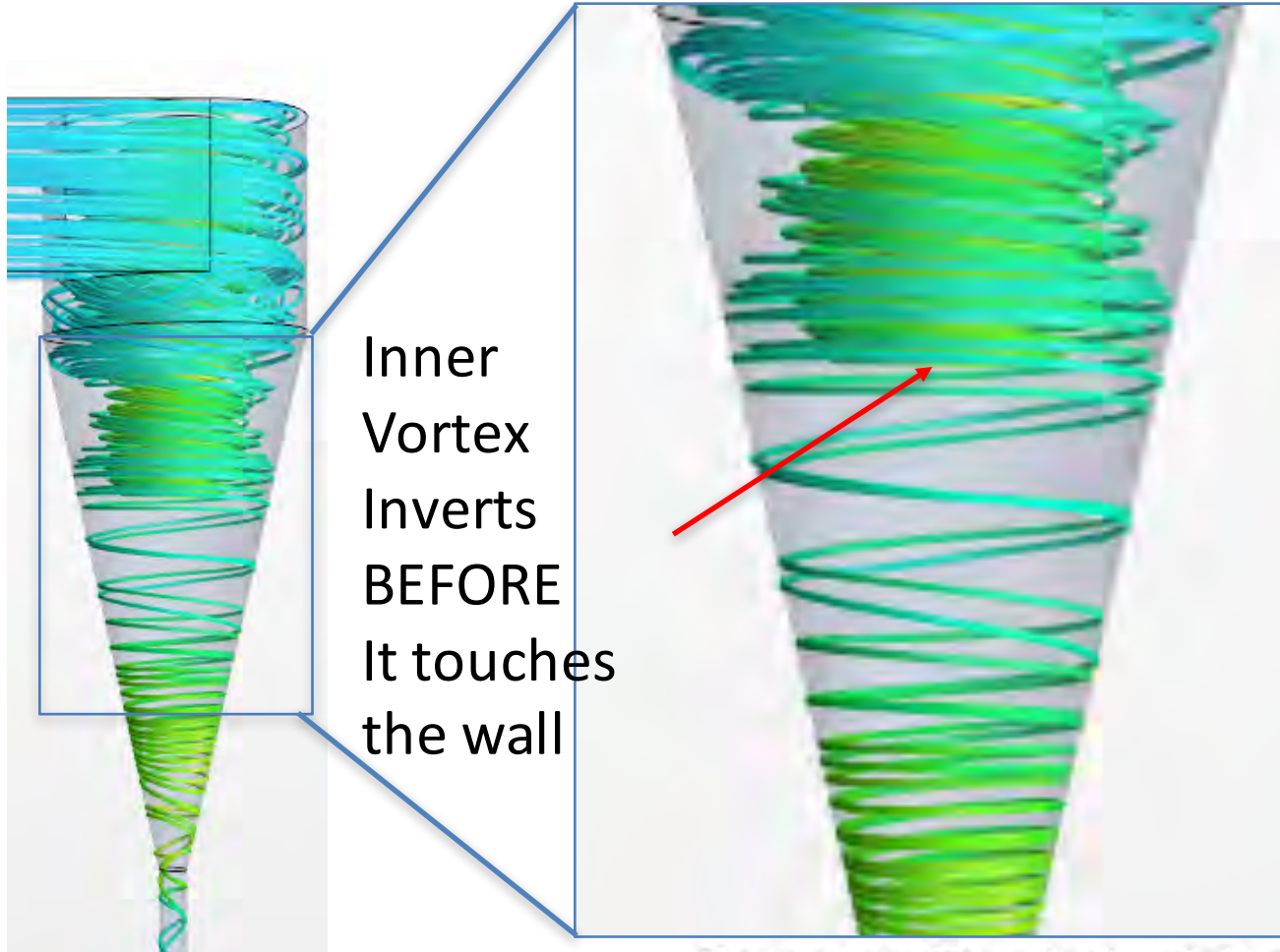


# Baseline Streamlines (exhaust side)



# Comparison of Simulation and Design Intent for Natural Length





# Overview of Simulation Approach

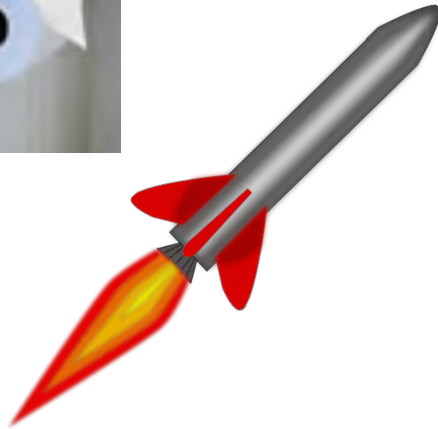
- Pressure drop compares reasonably well with estimates but there are some deficiencies in the steady state solutions
- Lack of convergence in RSM model may be mitigated by removing complexity of plenum/exhaust/return flow paths and just concentrate on a single cyclone
- Questions remain whether a purely hexahedral, structured, conformal mesh or an unstructured poly mesh are better choices for modeling a cyclone
- Flow fields travelling in opposite directions with just a thin shear layer between implies this is an inherently unsteady flow
- A transient-state solution averaged over an appropriate time interval yields a pseudo-steady-state solution that incorporates some effects of random turbulent perturbations in the flow stream
- This flow field can be “frozen” in time and used as the background continuum for the solution to the equations of motion in the Lagrangian particle calculations for collection efficiency simulations

This Innovation was/is TOO  
EXPENSIVE to test... so for 50 years...  
everything they owned and  
everything they bought new

HAS THE SAME PROBLEM!

UNTIL NOW

# *Rocket Science is necessary ?*



To improve  
*how we*  
make things  
for  
everyday  
life



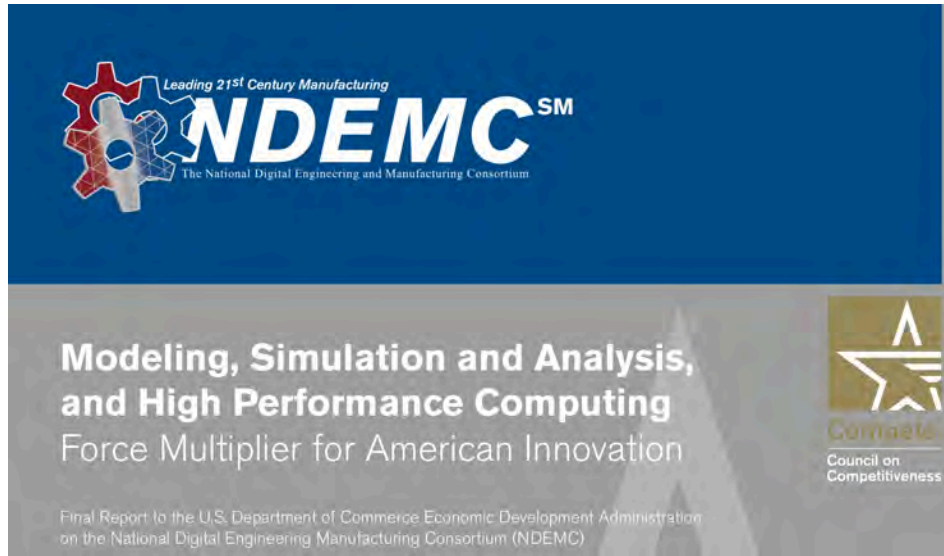
**OK... SIMULATION WORKS, WHY DO NOT MORE  
MANUFACTURES USE IT?**



## Barriers to M&S using HPC

- 1) Many Mfg's not embracing 'their survival dilemma' in HOW they make...because they see no usefule alternatives.
- 2) Validation: The 'Virtual World' still viewed as as NOT REALITY.
- 3) HPC availability ..NOT THE BARRIER. (The roads, rivers, wires and bandwidth are there). Barriers are pilots, guides and tickets to ride are too expensive (software).
- 4) Expertise is scarce and culturally 'strange' to plant floors.
- 5) Software is too expensive at 'wine by the glass'... Large companies build vineyards to use effectively.

**SOME THINGS HAVE BEEN TRIED**



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## NEWS

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By Patrick Thibodeau

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Computerworld | Nov 29, 2013 6:44 AM PT

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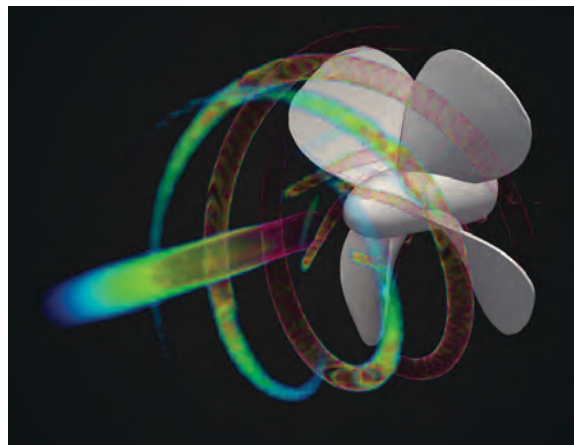
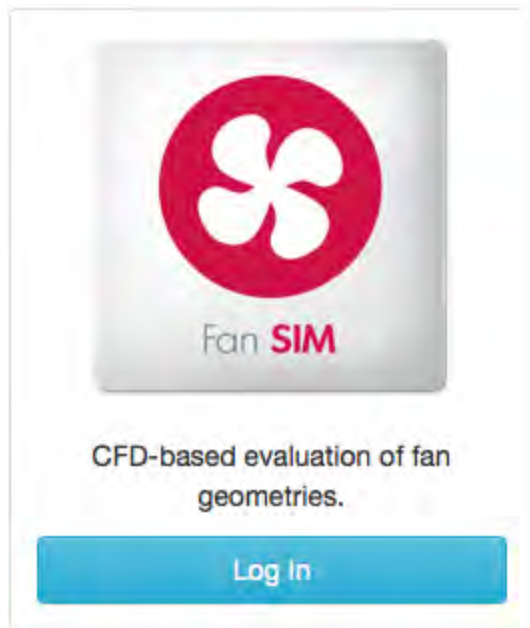
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**WHERE ARE WE TODAY?**

## What has Worked in Pilots.

- Affordable Software ‘by the drink’ ... App form even better.
- Engineering Service Providers (ESP’s) that can ‘face’ Manufacturers culturally...but sales cycle is expensive.
- Public – Private engagements that helped reduce the initial engagement barrier for both Mfg’s and ESP’s



## Future... What is needed.

- Computing, Software and Expertise Ecosystem with local ESP's capable of true realism for processes.
- More compelling Leadership Engagement, Story Telling, Outreach ... to get at these first two barriers...
  - 1) Many Mfg's not embracing 'their survival dilemma' in HOW they mfg...because they see no alternatives.
  - 2) Validation: The 'Virtual World' still viewed as as NOT REALITY.

# Expertise: What ESP's need

- Software that models reality... not some non-realistic, stylized view.
  - This is MUCH BETTER SCALING on FEA and CFD
  - This is MUCH BETTER SCALED COUPLING : DEM and CFD, FEA & CFD
  - Better 'Story Telling' Visualization Rendering... especially on Multi-physics simulations.
  - 'BY THE DRINK' software pricing they can include in affordable project proposals.



# QUESTIONS